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Measurement of Controlled Focused Sonic Booms from Maneuvering Aircraft

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13. ABSTRACT *(Maximum 200 words)*

In April 1994, the USAF Armstrong Laboratory in cooperation with USAF Test Pilot School conducted a measurement study of controlled focus boom generated by supersonic maneuvers. The objective of this study was to collect focus and post focus booms and to assess the ability of aircrews to control the placement of the focal region during basic maneuvers. Forty-nine supersonic passes were flown and included level linear acceleration, level turn, accelerating dives and climbout/pushover maneuvers. These flights were flown under calm and turbulent atmospheric conditions. Turbulent conditions had a defocusing effect which caused distortions in the focus region and resulted in smaller maximum overpressures. Sonic booms were collected by up to 25 Boom Event Analyzer Recorders (BEARs) placed in a 13,000 ft. linear array. The BEAR units were spaced 500 to 2,000 feet apart with the denser spacing at the expected focal region. This spacing was chosen to evaluate the thickness of both thte focal and post-focal regions. Of the 49 flights, a docus boom was placed within the array 37 times and within *±3,000 feet of the target point 27 times demonstrating the ability to place controlled focus booms.*

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PREFACE

This report is technical report describing the Have BEAR sonic boom database acquired by the Noise Effects Branch of Armstrong Laboratory in April 1994 at Edwards Air Force Base. This study was conducted under Project 7757, "Exploratory Noise and Sonic Boom Research." Partial funding for this effort was received from the US Air Force Test Pilot School.

The authors wish to acknowledge Mr. Michael Patterson of the University of Dayton Research Institute for his working and effort in maintaining and repairing the BEARs and all other ground support equipment. Without his efforts the test would not have been nearly as The authors also acknowledge the support provided by the USAF Test Pilot School staff and AF Flight Test Center staff at Edwards AFB. Finally, the authors wish to acknowledge Ms. Jackie Brennaman and Ms. Bea Heflin for their efforts in preparing this report for publishing.

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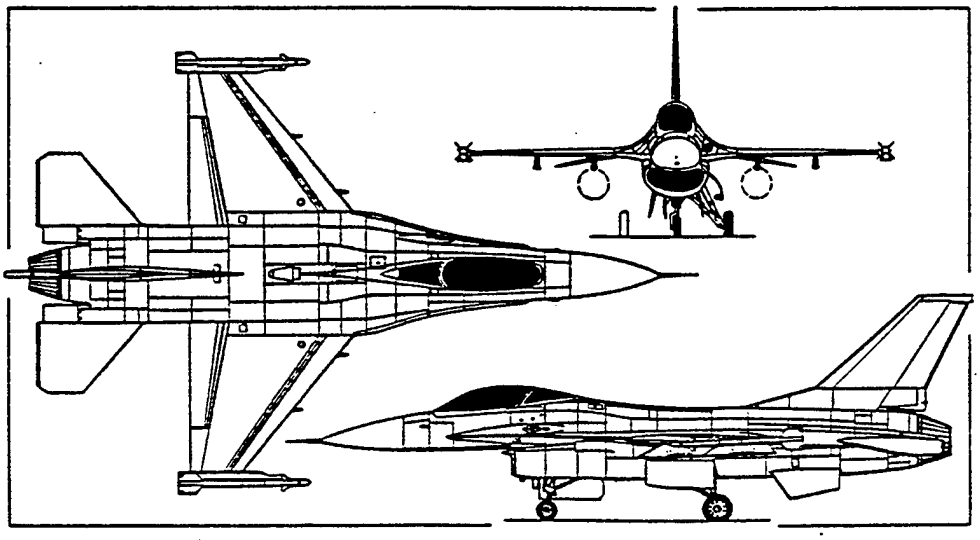
INTRODUCTION

Supersonic operations from military aircraft generate sonic booms that can affect people, animals and structures. A substantial experimental data base exists on sonic booms for aircraft in steady flight and confidence in the predictive techniques has been established. All the focus sonic boom data that are in existence today were collected during the 60's and 70's as part of the information base to the US Supersonic Transport program[1-4] and the French Jericho studies for the Concorde[5]. These experiments formed the data base to develop sonic boom propagation and prediction theories for focusing. There is a renewed interest in high-speed transports for civilian application[6]. Moreover, today's fighter aircraft have better performance capabilities, and supersonic flights are more common during air combat maneuvers. Most of the existing data on focus booms are related to high-speed civil operations such as transitional accelerations and mild turns. Military aircraft operating in training areas perform these types of maneuvers along with more drastic maneuvers such as dives and high-g turns. An update and confirmation of USAF prediction capabilities is required to demonstrate the ability to predict and control sonic boom impacts, especially those produced by air combat maneuvers.

In April 1994, the USAF Armstrong Laboratory in cooperation with USAF Test Pilot School conducted a measurement study of controlled focus boom generated by supersonic maneuvers[7]. This study had three main objectives: to test the ability of pilots to control the placement of the focus region, to validate prediction methods, and to evaluate the effects of atmospheric turbulence within the earth boundary layer on focusing. This study project was called 'Have BEARs' by the USAF Test Pilot School. This paper describes the test procedures and summarizes the measurements obtained from the test.

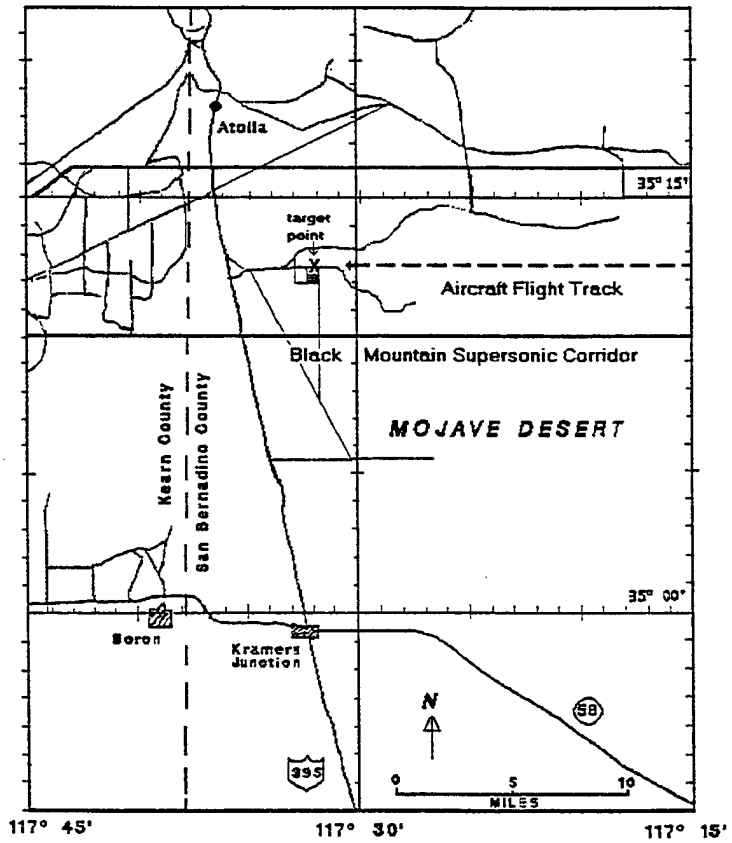
TEST PROCEDURES

The four air combat-type maneuvers used in the study were level acceleration, diving acceleration, constant g and Mach turn and a climbout/pushover. The test aircraft was the F-16B (Figure 1.). Test were conducted within the Black Mountain Supersonic Corridor at Edwards AFB (Figure 2) which had a ground height of 2,900 feet Mean Sea Level (MSL). The maneuvers were flown at 10,000 feet MSL except for the dives which were started at 20,000 feet MSL. This altitude range is common for military operations and differs from previous focus sonic boom measurements[1,2,3,5]. These flights were flown under calm and turbulent atmospheric conditions since previous studies[3,5] have suggested that turbulent conditions may defocus and distort the booms within the focus region. Except for the first day (12 April), a linear array of sonic boom monitors collected the sonic boom signatures along or parallel to the ground track (Figure 3). The length of the array varied during the test from 10,500 to 13,700 feet with 15 to 21 measurement sites. On the 12th of April, a two dimensional array was employed with 40 sites. However, equipment trouble required the linear array to used for the rest of the measurement study. It should be noted that the measurement sites were restricted to existing roads to avoid any disturbance to the desert habitat. The Boom Event Analyzer Recorders, (BEAR)[8], were used to measure the sonic boom waveforms. The spacing of the BEARs ranged from 500 to 2,000



Aircraft:	F-16	Height:	16.4 ft
Name:	Fighting Falcon	Wing Span:	31.0 ft
Engines:	(1) F100-PW-200	Wing Area:	300 sq ft
Thrust Per Engine:	25,000 lbs	Empty Weight:	15,140 lbs
Length:	47.6 ft	Gross Weight:	23,360 lbs

1. Planview drawing of F-16B aircraft



2. Area planview of the test area including flight track

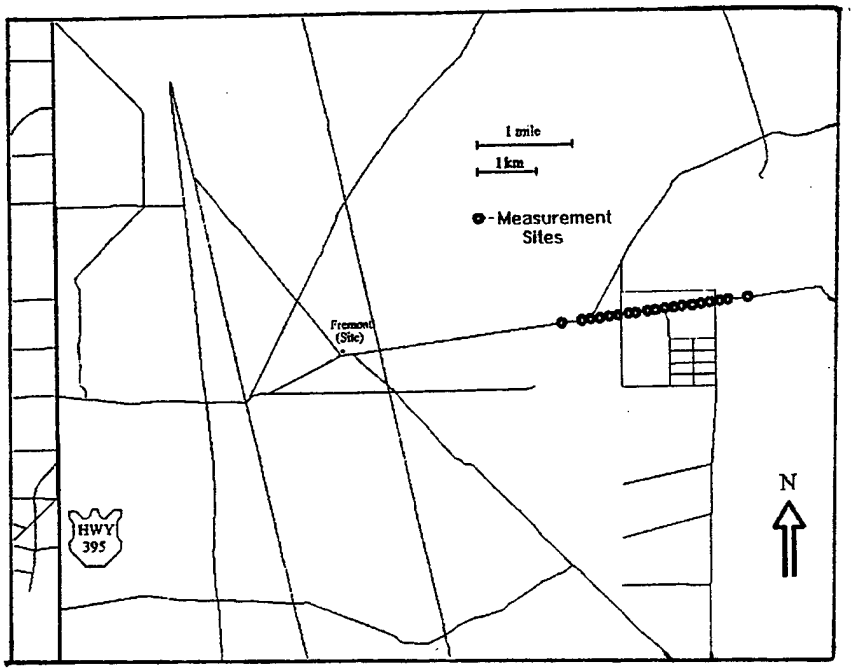


Figure 3. Planview of measurement site and location of monitors

feet. The closer spacing was within the planned focus region with the wider spacing for the pre- and post-focus and carpet region of the sonic boom footprint.

To predict the flight profile, F-16B horizontal acceleration rates, sustained turn rates, and constant speed climb rates were determined using specific excess power curves from the F-16B flight manual[9]. Aircraft performance predictions for acceleration rates were made for standard day and standard day plus 10 degrees Celsius conditions. With this information, acceleration rates, climb rates, and sustained turn rates were calculated, and the sonic boom footprint from this profile was predicted using a ray tracing sonic boom model, PCBoom3[10]. With the boom prediction, the flight profile for each pass was aligned with the array for proper placement of the focus region. The alignment provided the distance-to-target from the maneuver point. The aircrews programmed these distances into the on-board guidance system along with the appropriate initial and steady point.

The Black Mountain Supersonic Corridor was reserved from surface to 20,000 feet during all data runs to preclude noise interference from other aircraft activities. Ground personnel were stationed at specified locations throughout the array to provide real-time feedback to aid in determining the location of the sonic boom focus. Personnel uprange of the sonic boom focus should have heard no sonic boom. Personnel located in the vicinity of the focal region would hear a very loud "double boom" while those located downrange of the focus would hear a normal intensity "double boom" from the N-wave followed by a rumbling U-wave which indicated the trailing edge of the focal region. Feedback from these observers gave rapid qualitative feedback on the location of the focus. From this feedback, adjustments could be made to the timing of the

profile flown to best place the location of the focal region at the designated target point in the array.

For all testing, aircraft tracking data were gathered via the Advanced Range Data System (ARDS). The tracking data collection rate was 100 samples per second and included 14 different aircraft parameters such as time, position, Mach number, heading angle, dive angle, angle of attack, etc. This information was used in flight along with normal air-traffic control radar to provide course corrections to the aircrew for all runs except the autonomous level accelerations. Figure 4 shows an example of the flight track data for one of the level acceleration passes where the dots denote 10 second intervals. Appendix A contains plots of individual flight tracks for each pass. The aircraft flew in the negative x direction (due west) and broke the level acceleration off after passing the target point (0,0) by climbing above 20,000 ft MSL to regain potential energy.

Rawinsonde balloon launches were scheduled within one hour of each test sortie launch time to gather atmospheric profile data. Data included temperature, pressure altitude, wind speed and direction aloft, and relative humidity. As a backup to rawinsonde balloon data, the aircrew recorded inertial navigation system (INS) wind data from the Heads-Up Display (HUD) via the aircraft video tape recording (VTR) system. During the climbout, the pilot qualitatively assessed turbulence. Prior to each run, inertial winds at altitude were recorded by aircrew by hand and on the VTR tape. Surface temperature, wind speed and direction, and relative humidity were measured at the test site and collected as one minute averages with extremes. Appendix B contains rawinsonde atmospheric profiles and surface weather data collected during the study.

Description of the four maneuvers

Figure 5 provides a sketch of the flight profiles of the four maneuvers performed during this test. The sketch provides the main points of the profiles: initial, steady, maneuver, mach one (level and diving accelerations), and break points. Also the sketches shows the relationship between the maneuver point to the target point. For the level and diving accelerations the flight track was in line with the array, while the turn and climbout/pushover flight tracks were parallel to the array but offset to the south of the array.

The level acceleration profile (Fig. 5a) was the priority profile for data collection purposes since it was the easiest profile for the aircrews to become proficient for the autonomous runs . Prior to initiation of the maneuver, the test aircraft was stabilized at 0.9 Mach number and 10,000 feet pressure altitude. At initiation of the maneuver, the pilot selected full afterburner and accelerated on course to 1.2 Mach number. Course corrections were provided up to the maneuver point by controllers based on real-time display of ARDS data and were limited to five degrees of bank or less. The pilot would call the transition point when the aircraft speed reached Mach 1.0. The maneuver was terminated as the aircraft flew over the array, or reached 1.2 Mach number, whichever occurred first. Several autonomous flights were performed with the linear acceleration to test the feasibility of pilots placing the focus region at the target point without external real-time guidance. For the autonomous runs before each flight, distance-to-target data from the maneuver point for each pass were calculated. These data were used by the aircrews as an input to the on-board guidance. Minor corrections to the distance-to-target from the

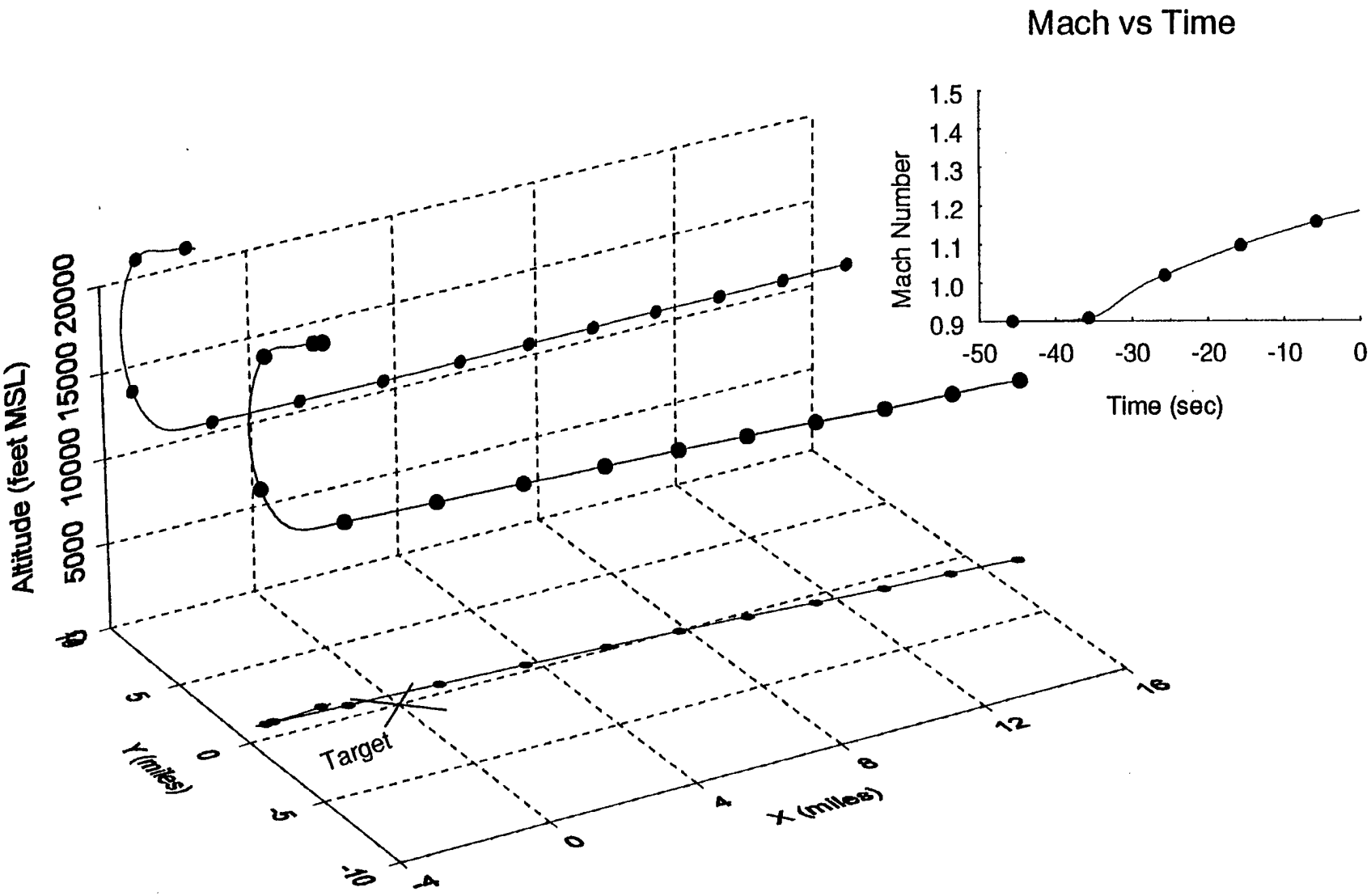


Figure 4. Sample of the actual flight profile. Note, dots appear at 10 second intervals for reference. The data was collected at 100 samples per second.

maneuver point, if required, were given only between passes. However, no other corrections were given to the aircrews during the autonomous runs.

For the diving accelerations (Fig. 5b), the aircraft was stabilized in level flight at 0.9 Mach number and 20,000 feet pressure altitude prior to maneuver initiation. At the maneuver point, the pilot selected full afterburner, rolled inverted, performed a 4g pulldown to a 30-degree nose low attitude on the flight path marker, and rolled upright while maintaining the stable dive. The roll maneuver was performed with the dive since this is common for the initiation for a high degree dive and it ensures a crisp dive profile. No course corrections were provided after initiation of the maneuver. The pilot called the Mach 1 point as the aircraft transitioned into supersonic flight. The maneuver was terminated as the aircraft reached 1.2 Mach number or descended below 13,000 feet pressure altitude.

For the constant-g and Mach turn (Fig. 5c), a load factor of 4g was chosen as a maximum sustainable load factor for the turn maneuver while trying to maintain 1.2 Mach number. Before the maneuver, the aircraft was stabilized in level flight at 1.2 Mach number and 10,000 feet pressure altitude. At the start of the turn, the pilot selected full afterburner and initiated a 4 g level turn. The maneuver was terminated after 50 degrees of turn, and the pilot called the break point.

The climbout/pushover maneuver (Fig. 5d) included two supersonic flight segments, a climbout followed by a pushover to level flight. Prior to the climbout, the aircraft stabilized in level flight at 1.2 Mach and 10,000 feet pressure altitude. At the climbout point, the aircraft would start a ten degree climb while maintaining 1.2 Mach. Once the climbout angle and speed were stabilized, the pilot pushed the aircraft over with a load factor of 0.5 g to the level flight attitude while maintaining constant Mach number. The maneuver was terminated as the aircraft reached the level flight attitude. During this profile the pilot called the climbout, pushover and break points while receiving guidance. The focus boom created by this maneuver was generated at the pushover point and occurred lateral to the centerline of the flight track. Thus, the flight track was offset 13,700 feet south of the array.

RESULTS

For the overall study, 49 maneuvering passes were performed: 31 level accelerations (11 of which were autonomous passes), nine diving accelerations, seven 4g turns, and two climbout/pushovers. The aircrews were successful in placing a focus boom within the array 37 times out of these 49 passes and within ±3,000 feet of the target point 27 times. Tables 1 - 5 list the summary information for the individual passes. Of the twelve 'misses', the focus was produced in front of the array five times and behind the array only once. For five passes, turbulence distorted the sonic boom within the array so that a focus region could not be clearly defined. The separation time of the leading shocks between the N and the U wave was used to estimate the location of the onset of the focus region. Note, for the table and the following boom signature plots, the zero point is the target point, positive distance is uptrack of the target, and negative is downtrack. Appendix C contains plots of the boom data collected with the linear

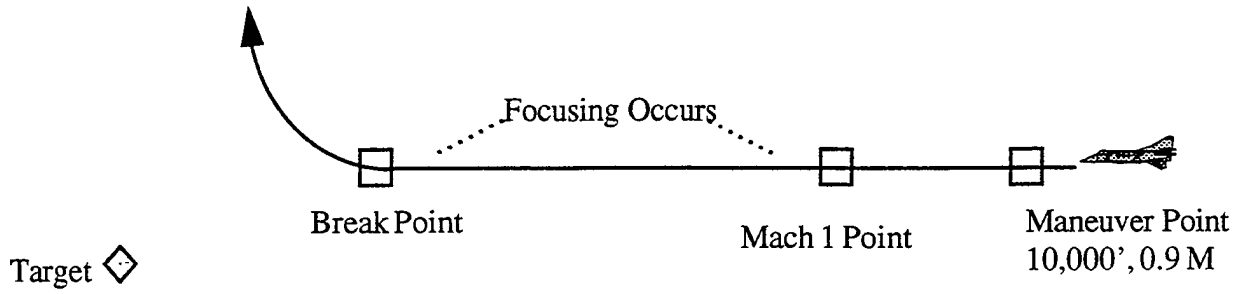


Figure 5a. Level Acceleration Profile (Side View)

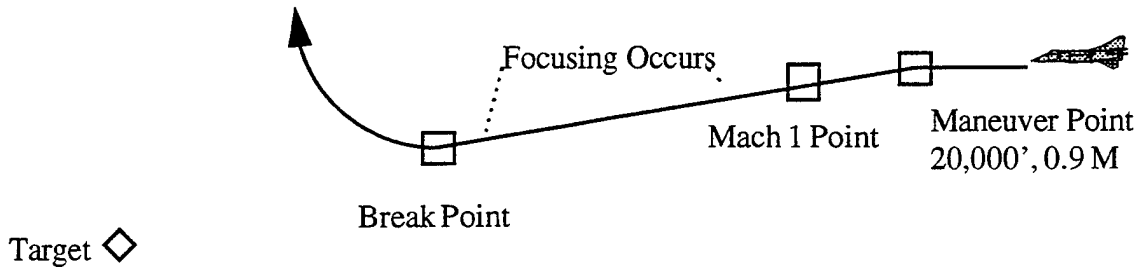


Figure 5b. Accelerating Dive Profile (Side View)

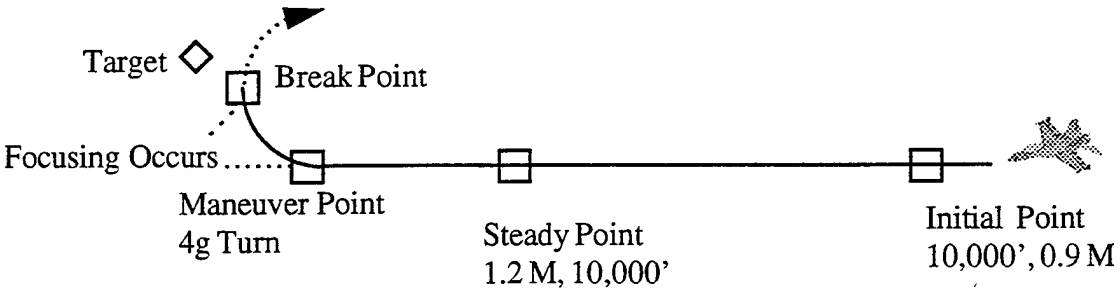


Figure 5c. Constant Mach/ g Rate Turn Profile (Overhead View)

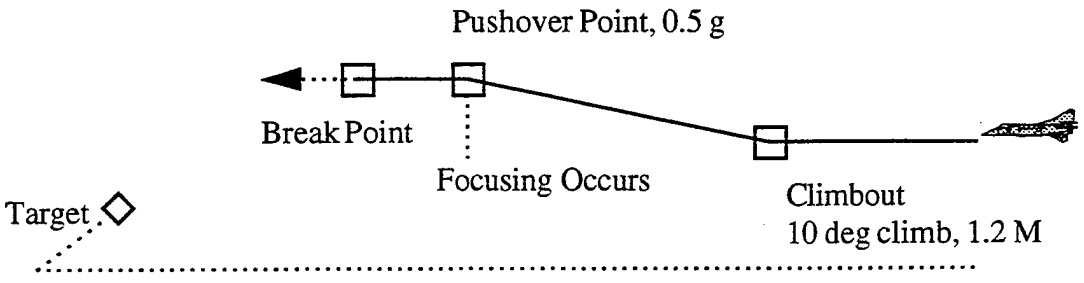


Figure 5d. Climbout/Pushover Profile (Side View)

array and is grouped by pass. Note, the signature data from 12 April is not included in this report but is included along with site locations in the ditigal database. Appendix D contains the notes from the flight controller. These notes include observations and commentary about the test and data collections procedures.

Level Acceleration

One objective of this test was to test the ability of pilots to control the placement of the focus region. In summarizing the statistics of the focus boom placement for the level acceleration profiles (Tables I and II), the data is grouped into three different sets: total, calm atmospheric conditions, and autonomous run passes. The total group includes 25 passes and excludes two passes where atmospheric turbulence in the earth boundary layer defocused the boom and four passes where insufficient boom data were collected. For this group the focus boom had a mean placement of -1150 feet downtrack from the target point with a standard deviation of 3230 feet. The calm atmospheric conditions group that includes passes flown in the morning includes eight passes. The mean placement of the focus boom for this grouping was -60 feet from the target with a standard deviation of 2660 feet. The autonomous run group (Table II) includes nine passes and excludes two passes in which turbulence severely distorted the focusing of the boom. For this group the focus placement had a mean of +1060 feet uptrack from the target point with a standard deviation of 980 feet. In comparing these different sets, the placement precision for the autonomous passes demonstrates the ability of the aircrews to control the placement of the focus region and of current USAF sonic boom prediction program[10] to plan supersonic profiles. However, atmospheric turbulence greatly diminishes this ability since turbulent conditions defuses the focusing of the booms.

Three level accelerations passes are considered in detail to show some the effects of atmospheric turbulence on sonic boom focusing. The first boom series was measured during calm atmospheric conditions, the second one during thermally turbulent conditions (low winds, high solar heating), the third series during mechanical turbulence (gusting winds, low heating). The aircraft acceleration rates for these three atmospheric situations is given in Figure 6 which shows the Mach number versus time for each of these flights. This plot shows that the acceleration rates were fairly consistent between the flights. For flight during thermal turbulence, the actual acceleration was less than the other cases which would result in the focus region occurring slightly further downstream. Figure 7 shows the boom signatures recorded along the array for pass 46 that was flown during calm atmospheric conditions. The booms are aligned in relative time to the leading shock. The first boom recorded was 500 feet uptrack of the target point and had a peak overpressure of 10.8 psf. However, the maximum measured peak overpressure of 19 psf occurred at the target point. Figure 7 shows the increased separation between the N and U waves with distance from the focus region. The comparison between the amplitude of the N and U waves, Figure 8, shows the amplification of the peak overpressure within the focus region. For this case the amplification factor was 3.8 when compared to the predicted carpet boom overpressure of 5.0 psf for steady flight conditions of 1.2 Mach at 10,000 feet. This plot also shows the decay of the post-focus U wave amplitude as it moves from the focus region[2-5].

Figure 9 shows the signature computed from PCBoom3[10], using the actual flight profile of pass 46. Comparing these signatures to the measured signatures of Figure 7, it appears that the

Table 1. Level Linear Accelerations (Guided) Focus Boom Placements

Pass No.	Date	Time (PDT)	Focus Location from target (feet)	Comments	Atmospheric Conditions
1	12 Apr 94	9:23:27	-2880		Sunny with high scattered clouds. 70-71° F at test site Winds at 1.0 knots gusting to 4 knots. 16% Rel. Hum.
2		9:29:01		Focus in array, no boom data	
3		9:32:12	960		
4		9:35:32	-5120		
5		9:39:06	3000	Focus up track of array	
6		9:43:55		Focus in array, no boom data	
7		12:10:20	-5690		Sunny with high scattered clouds. 68-70°F at site. Winds at 5 knots gusting to 8 knots. 7% Rel. Hum.
8		12:16:43		Focus in array, no boom data	
9		12:23:22	-1370		
10		12:27:36	-2580		
11		12:53:17		Focus in array, no boom data	
12		12:59:39	1900		
13		13:05:26	-3050		
23	13 Apr 94	12:34:47	0		Sunny with high scattered clouds. 63-65°F at site. Winds at 2.5 knots gusting to 5 knots. 9 % Rel. Hum.
24		12:40:23	-7000	Distorted focus region	
25		12:45:16	-3000		
26		12:49:48	~2000/ -8390	Multiple focus regions	
27		12:52:09	-1120		
28		13:00:43	-6940		
29		13:05:42	~-7500		

Table 2. Level Linear Accelerations (Autonomous) Focus Boom Placements

Pass No.	Date	Time (PDT)	Focus Location from target (feet)	Comments	Atmospheric Conditions
39	20 Apr 94	15:19:32	+1520/ -6870	Multiple focus regions	Sunny, clear skies. 95-97°F at site. Winds at 4 knots gusting to 8 knots. 8% Rel. Hum. Thermal turbulence
40		15:25:09	0/-7390	Distorted focus regions	
41		15:30:05		Defocused	
42		15:35:33		Defocused	
43	21 Apr 94	7:40:58	+1940		Sunny, clear. 61-63°F at site. Winds at 2.5 knots gusting to 5 knots. 50-46% Rel. Hum.
44		7:47:00	+80		
45		7:52:34	+1120		
46		7:58:06	+440		
47		16:51:50	+2860		Sunny clear, stiff winds at altitude. 81°F at site. Winds at 11 knots gusting to 20 knots. 15% Rel. Hum. Mech. Turb.
48		16:58:59	+1440	Distorted focus regions	
49		17:06:09	+140		

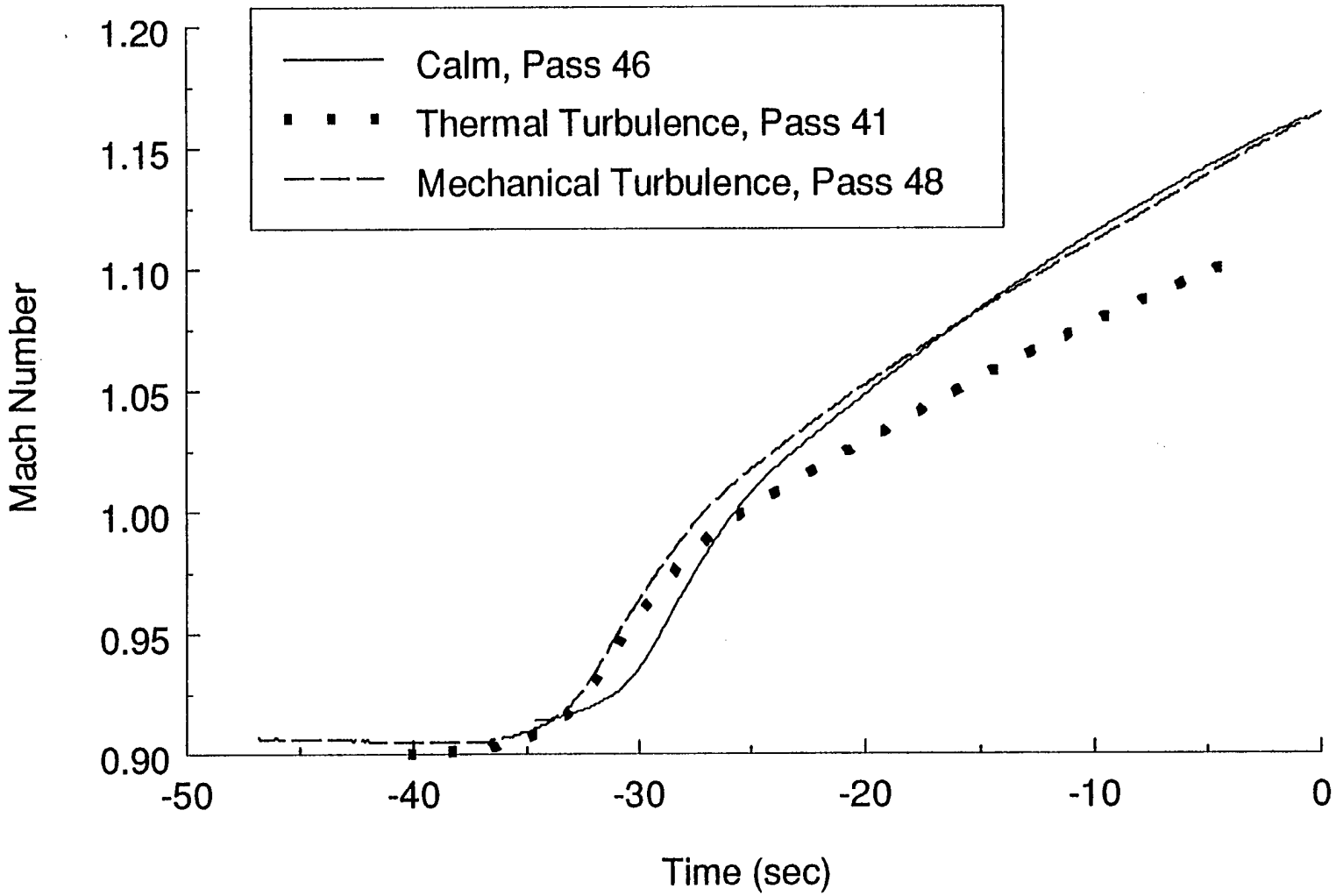


Figure 6. Mach number vs. time for the level accelerations during calm and turbulent atmospheric conditions. (Note time is relative to aircraft crossing target point.)

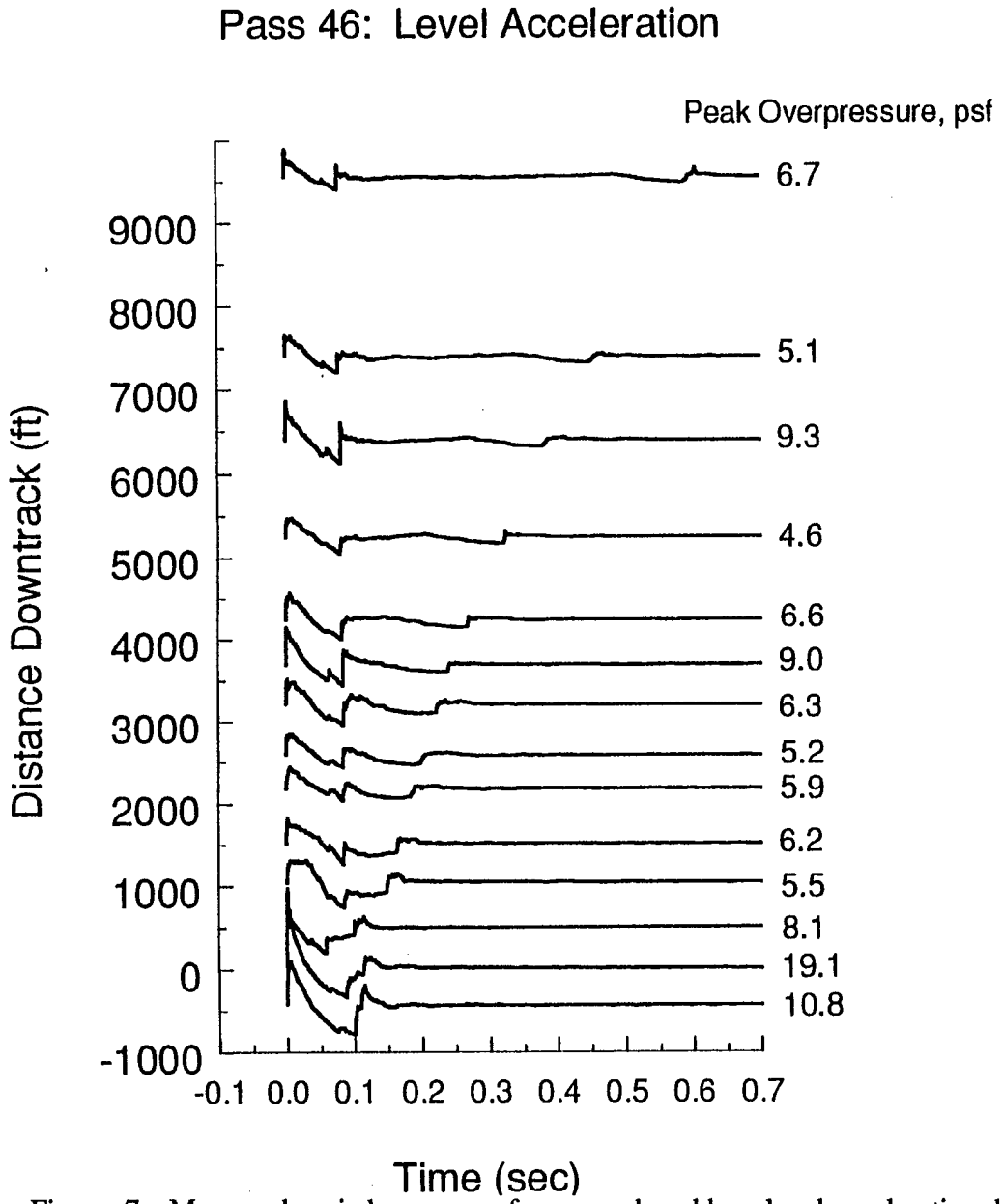


Figure 7. Measured sonic boom waveforms produced by a level acceleration during calm atmospheric conditions, Pass 46. (Signatures are aligned in time relative to the leading shock.)

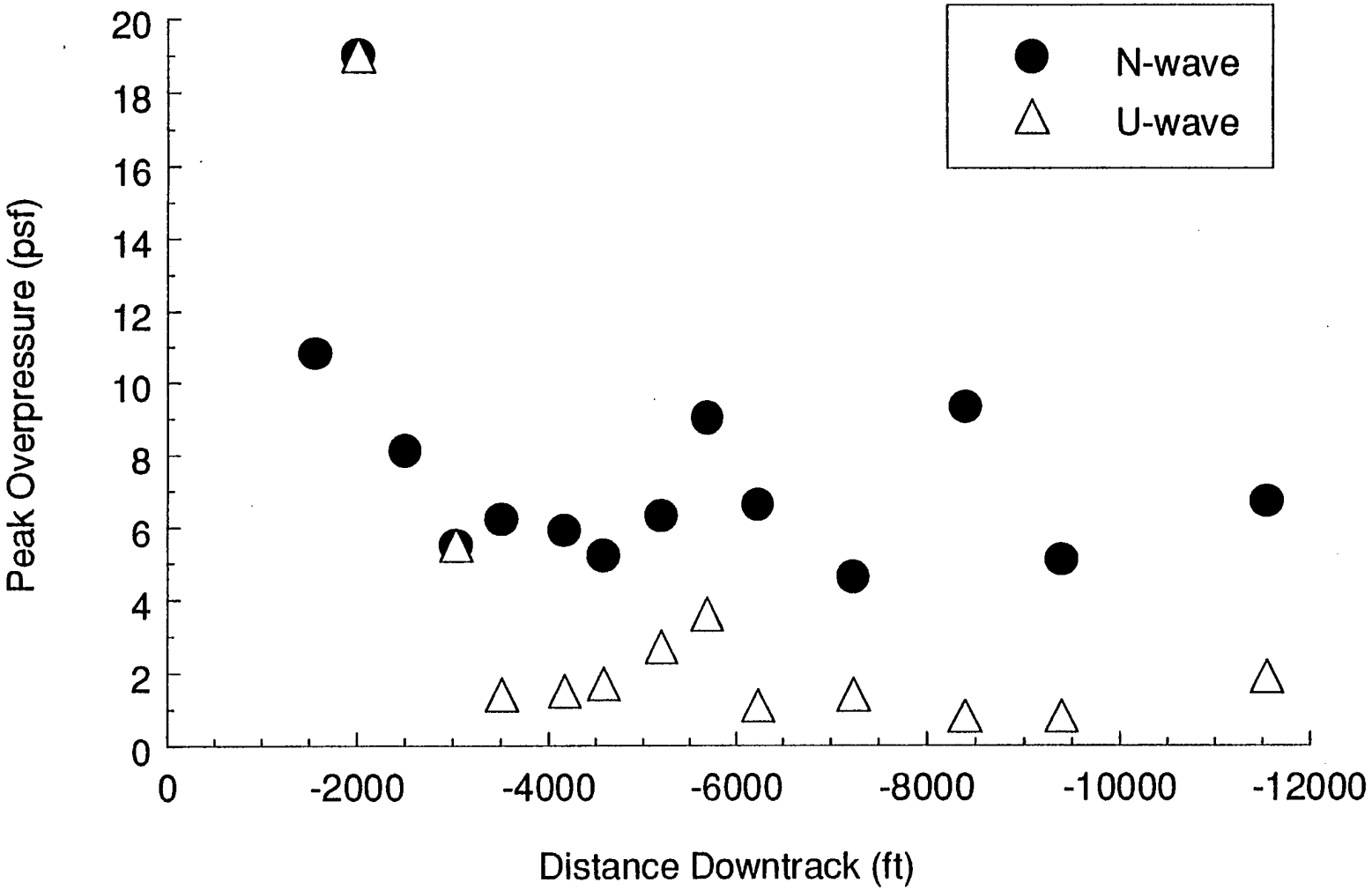


Figure 8. N and U wave peak overpressures vs. distance down track of focal zone for a level acceleration flight during calm atmospheric conditions, Pass 46.

predicted focus is slightly too far uptrack and the N-U separations are larger than measured. However, the focal zone methodology in PCBoom3 applies a numeric focus solution by Gill and Seebass[11] to the linear ray acoustic caustic location. The Gill-Seebass solution shows non-linear distortion of the ray geometry, with the focus occurring slightly above the caustic. This displaces the focus downtrack. For the conditions of the Pass 46 focus, this displacement has been calculated to be 3,500 feet. Applying this offset, the measured and predicted N-U separation are in very good agreement. The offset predicted focus location is then about 1,500 feet downtrack of the measured focus, but this is associated with nonlinear displacement in the Gill-Seebass solution and is also a distance comparable to the focal zone dimension. The predicted overpressures also agree well with the measurements.

The second boom series, as shown in Figure 10, was measured during thermally turbulent conditions. The surface conditions were hot with a temperature of 97°F with no sustained winds and a few minimal wind gusts to 1.0 knots. This series demonstrates no clear focus region although the acceleration profile is similar to the previous case, pass 46. The maximum peak overpressure was 10.0 psf and occurred 5,250 feet downtrack from the target point which can be expected from the reduced acceleration rate. For this pass the amplification factor was reduced to 2.0.

The third boom series, shown in Figure 11, was measured during mechanically turbulent conditions. The surface conditions were mild with a temperature of 81°F with a sustained head wind of 14 knots with gusts to 18.5 knots. This series is drastically different since two focus regions occurred within the array. The first focus region was at 500 feet uptrack of the target point and had a peak overpressure of 20.9 psf, amplification factor of 4.2. The second region was at 7,000 feet downtrack of the first and had a peak overpressure of 19.3 psf, amplification factor of 3.4. The last measured signature shows two post-focus U wave trailing the N wave. These two boom series signatures suggest that turbulent conditions can minimize and distort the focus region and its amplified peak overpressures.

Dive

The summary information on the nine diving acceleration passes is provided in Table 3. The boom series for Pass 20 is shown in Figure 12 and is representative of the data collected for this maneuver. The maximum boom was 7.2 psf and measured 1,380 feet uptrack from the target point. This series shows that the post-focus region is narrower than the level acceleration maneuver since the post-focus U wave moves away from the N wave at a quicker rate. This narrowing of the focus region is demonstrated in Figure 13 that shows the predicted footprints for both the level acceleration and the accelerating dive. This comparison shows that the focal region of the dive is much narrower than the level acceleration even though the focal region is wider. Figure 14 shows the peak overpressures of the N and U waves measured along the array. Within the focus region the peak overpressure was amplified by a factor of 2.3 when compared to the predicted carpet boom overpressure of 3.2 psf from a level flight at 1.2 Mach at 15,000 ft. This maneuver had the most difficulty in placing the focus boom at the target point because of the narrowing of the focal region and the sensitivity of the focus location to the actual dive angle.

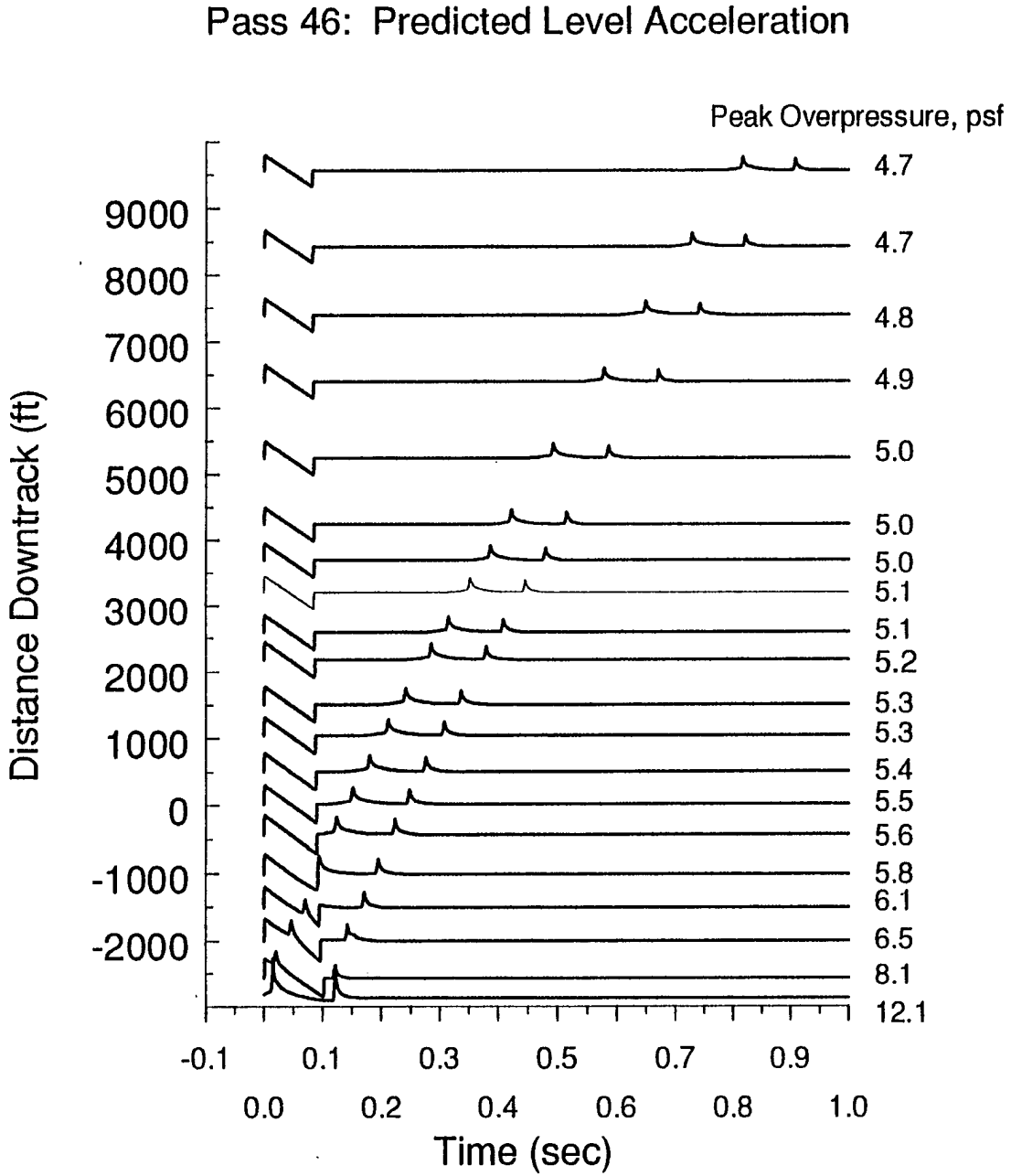


Figure 9. Predicted sonic boom waveforms produced by a level acceleration during calm atmospheric conditions, Pass 46. (Signatures are aligned in time relative to the leading shock.)

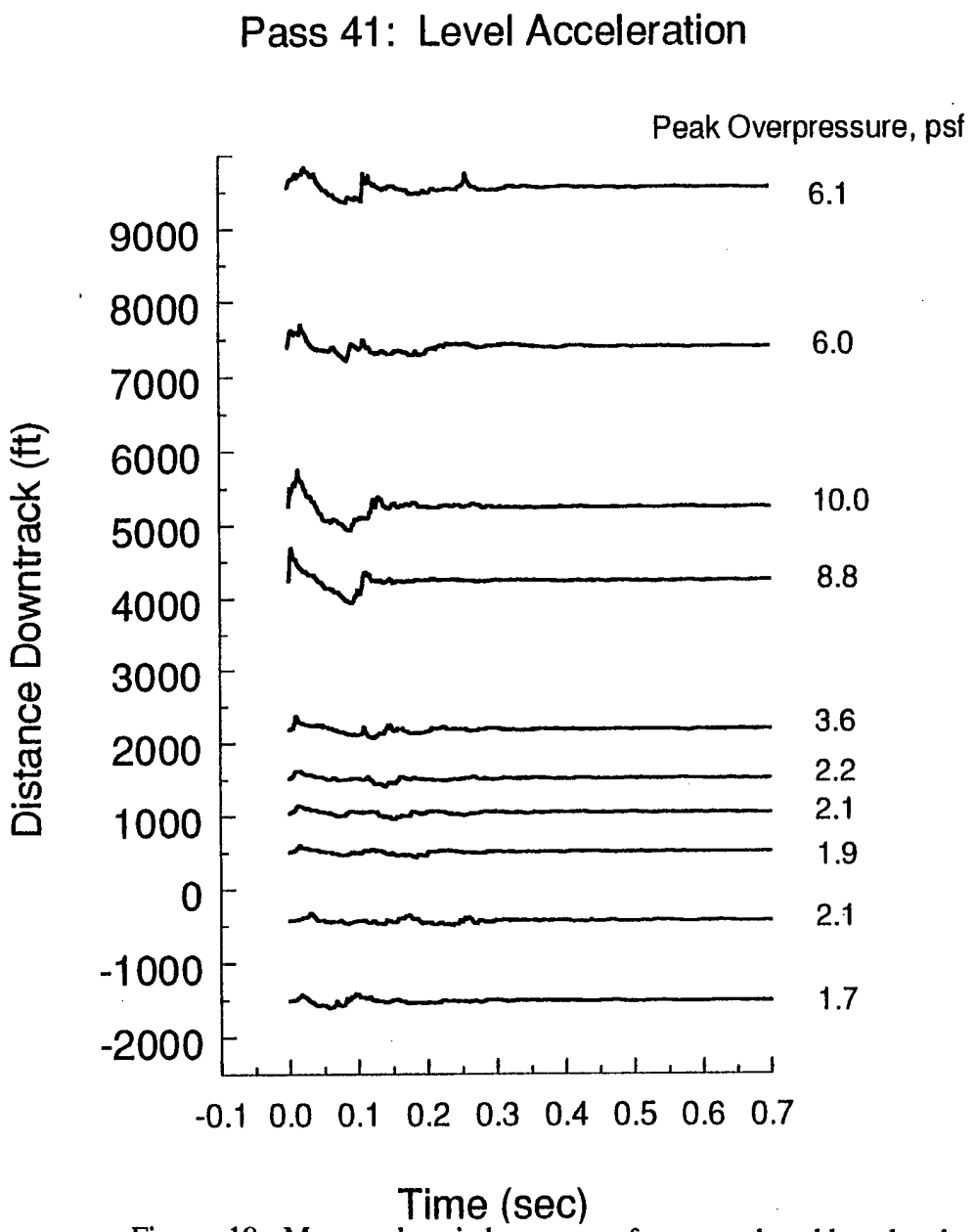


Figure 10. Measured sonic boom waveforms produced by a level acceleration during thermally turbulent atmospheric conditions, Pass 41. (Signatures are aligned in time relative to the leading shock.)

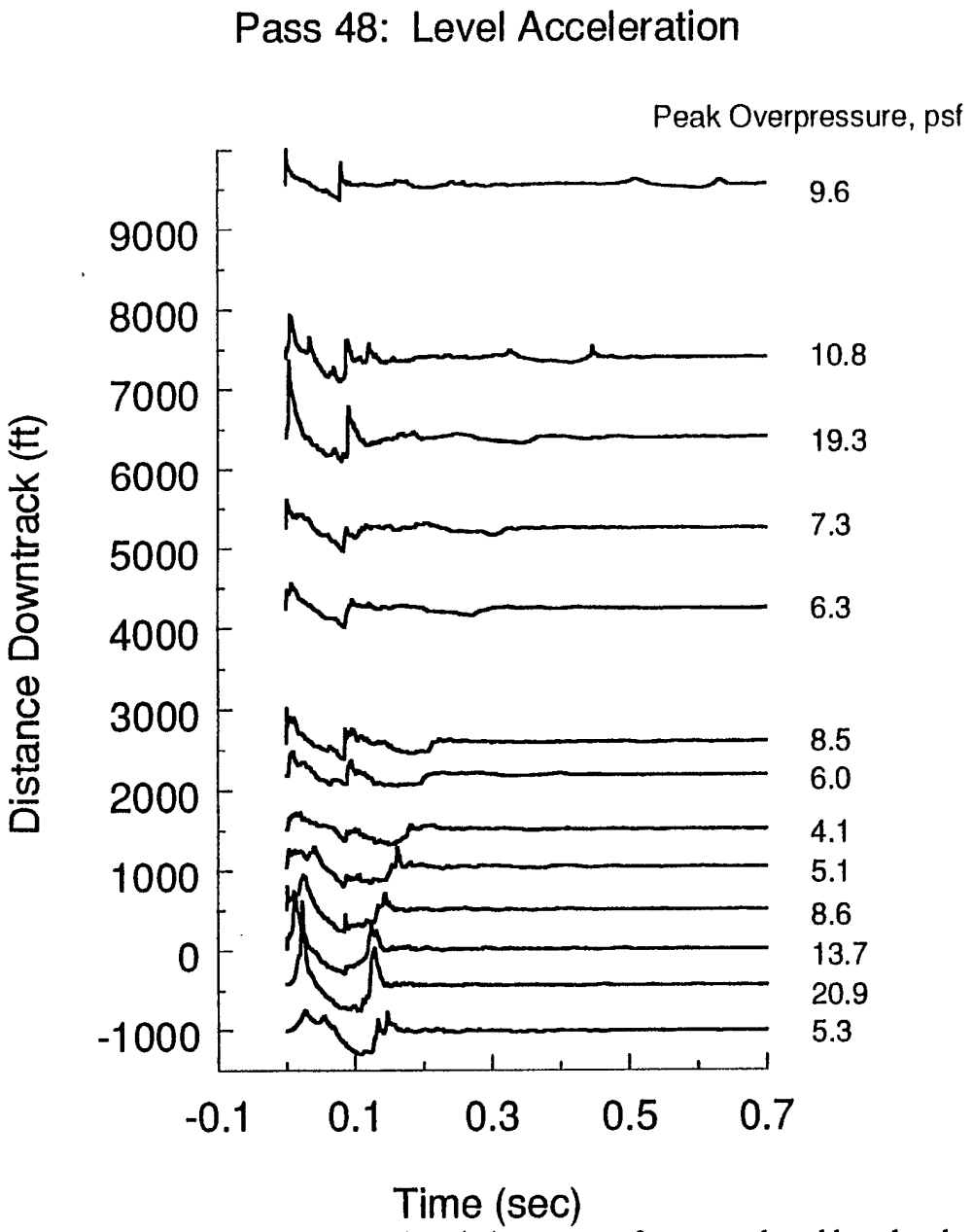


Figure 11. Measured sonic boom waveforms produced by a level acceleration during mechanically turbulent atmospheric conditions, Pass 48. (Signatures are aligned in time relative to the leading shock.)

Table 3. 30° Diving Acceleration Focus Boom Placements

Pass No.	Date	Time (PDT)	Focus Location from target (feet)	Comments	Atmospheric Conditions
14	13 Apr 94	9:42:11		Missed array to west	Sunny, high scattered clouds. 55-58°F at site. Winds at 3 knots gusting to 7 knots. 19% Rel. Hum.
15		9:47:41	~-8000	Estimated from Observations	
16		9:52:53	-4450		
17		9:57:23	+2213	Focus up track of array	
18		10:10:00	+3950	Focus up track of array	
19		10:19:24	+2800	Focus up track of array	
20		10:25:56	+1450		
21		10:28:40	+2160		
22		10:35:50	+4930	Focus up track of array	

Table 4. Level 4g Turn Focus Boom Placement

Pass No.	Date	Time (PDT)	Focus Location from target (feet)	Comments	Atmospheric Conditions
30	15 Apr 94	12:18:28		Distorted	Sunny, clear. 65-66°F at site. Winds at 7 knots gusting to 14 knots. 8% Rel. Hum.
31		12:21:39		Distorted	
32		12:24:45	+1500/ -6390	Multiple focus regions	
33		12:28:45		Distorted	
34	18 Apr 94	12:05:23		Aborted Run	Sunny, high clouds. 91°F at site. Winds at 3 knots gusting to 8 knots. 39% Rel. Hum.
35		12:11:15	-900		
36		12:17:05	-1920		

Table 5. Climbout/Pushover Focus Boom Placement

Pass No.	Date	Time (PDT)	Focus Location from target (feet)	Comments	Atmospheric Conditions
37	19 Apr 94	12:21:00	-170		Sunny, high scattered clouds. 90-91°F at site. Winds at 2 knots gusting to 7 knots. 21% Rel. Hum.
38		12:28:00	+2440		

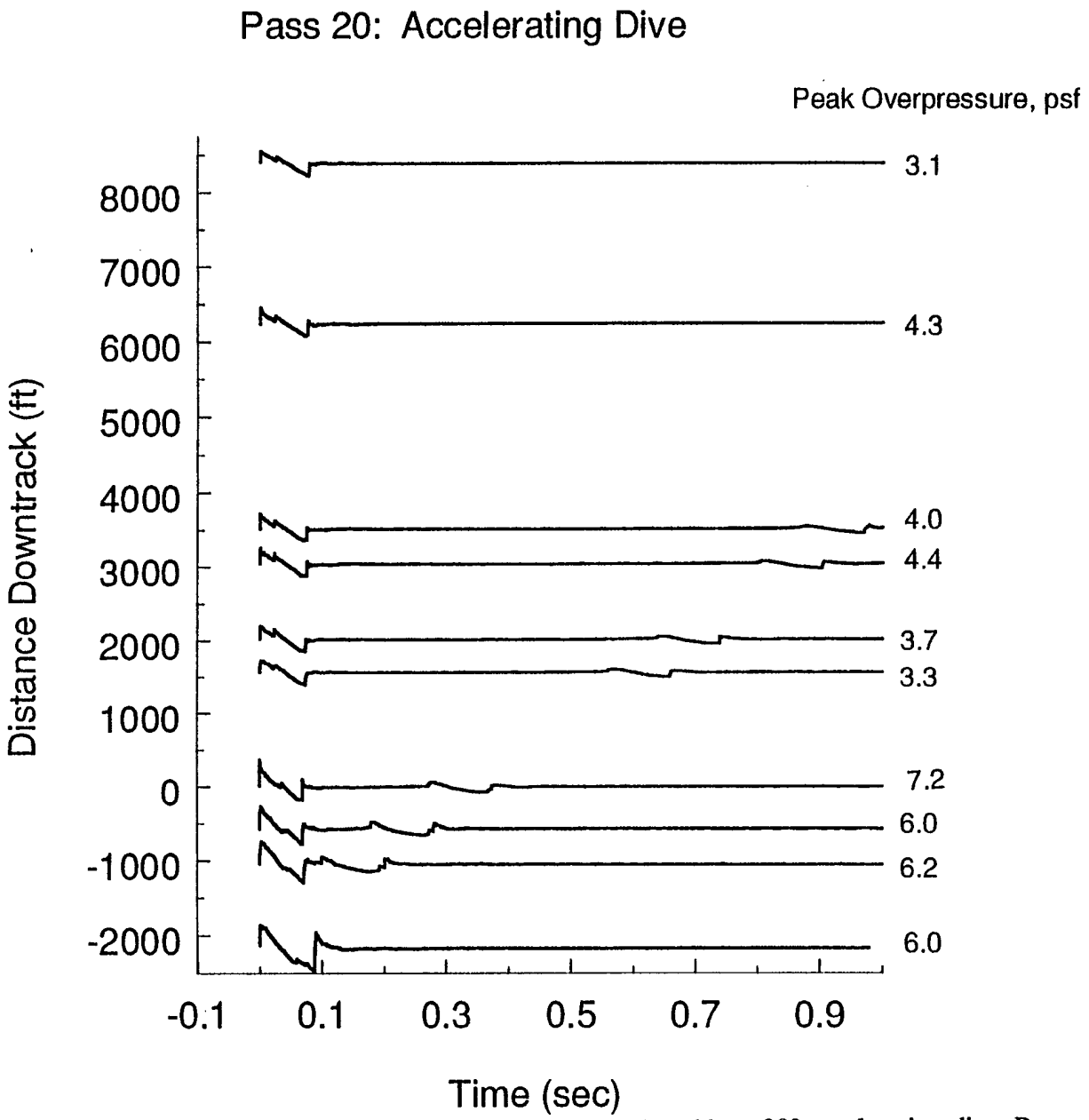


Figure 12. Measured sonic boom waveforms produced by a 30° accelerating dive, Pass 20. (Signatures are aligned in time relative to the leading shock.)

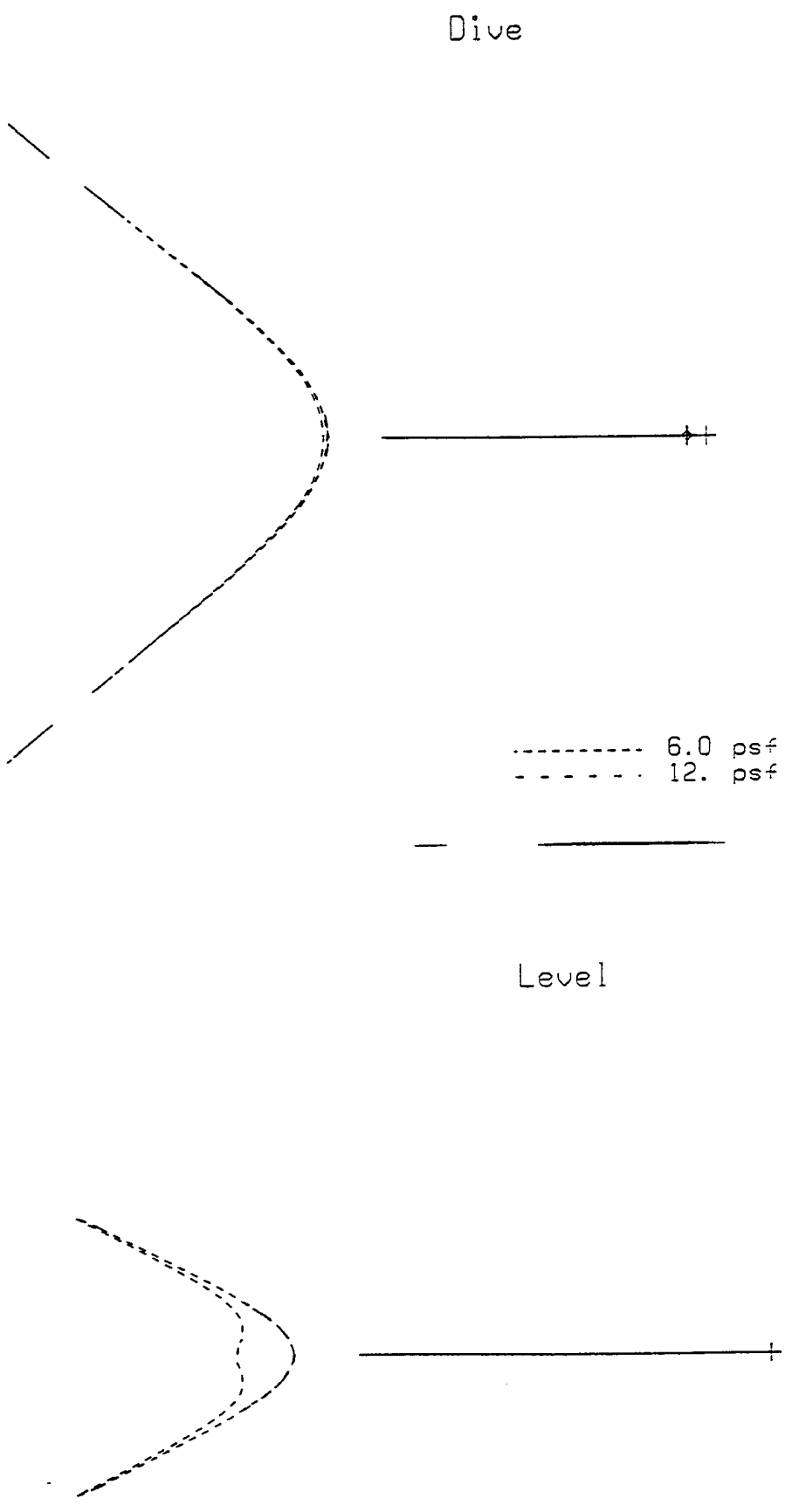


Figure 13. Focal Boom footprint contours from level acceleration and accelerating dive

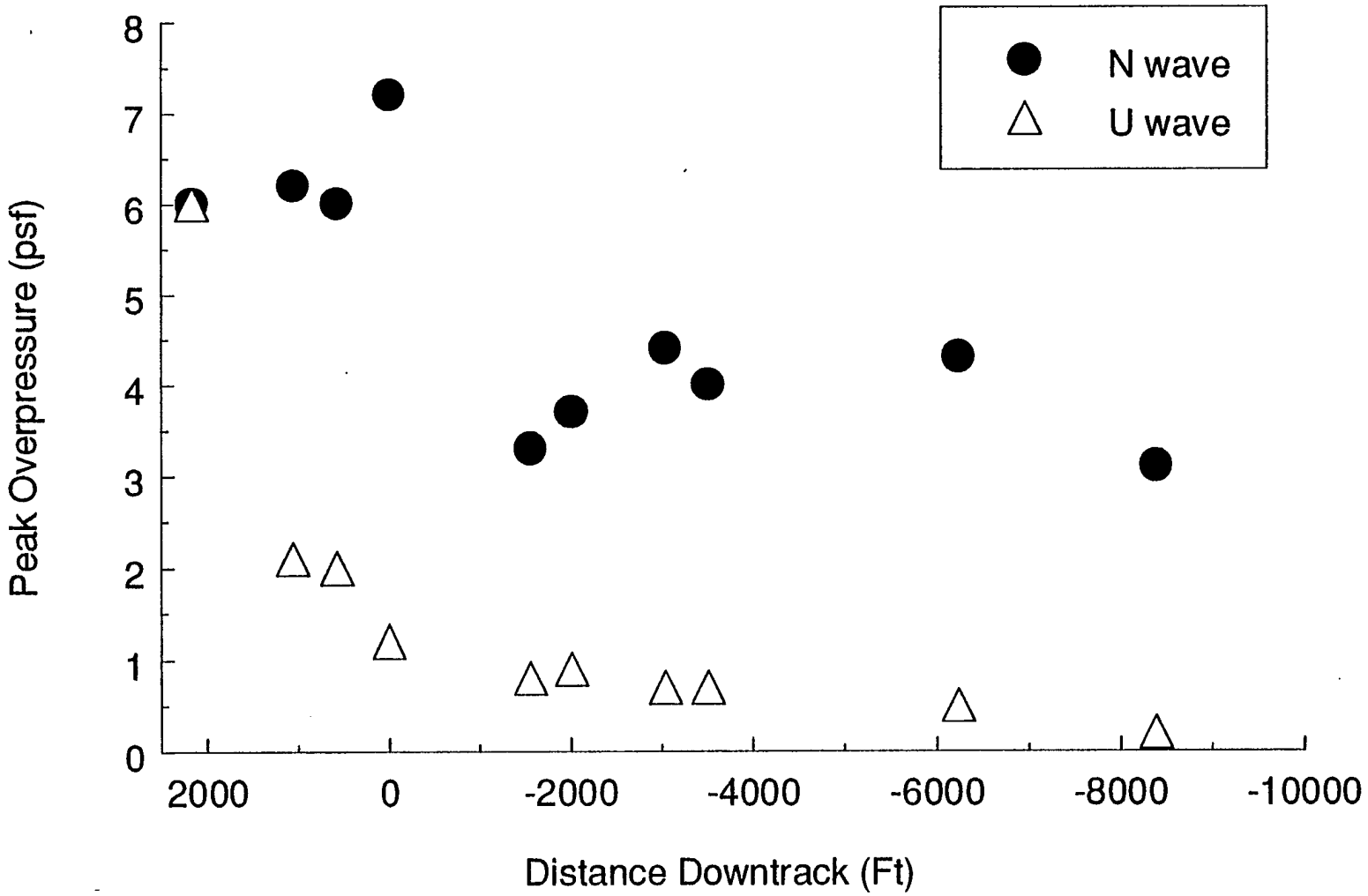


Figure 14. N and U wave peak overpressures vs. distance down track of focal zone for a 30° accelerating dive, Pass 20.

Turn

The next boom maneuver was a 4g turn at a Mach number of 1.2. The profile was aligned with the array so that the array would capture the focal line from the steady part of the turn and not the superfocus region generated by the initiation of the turn. Seven passes were performed with this maneuver and Table 4 lists the summary information from these passes. The measured booms from Pass 36 are shown in Figure 15. At the first part of the array, the measured booms were from the steady portion prior to the maneuver point. Focusing was measured within a band of 2,500 feet about the target point with the maximum overpressure measured at -1,500 feet from the target. This shows that focal line is very narrow for this maneuver. Post-focus signatures or disturbances appear in both directions from the focus region. The maximum overpressure was 8.7 psf which gives an amplification factor of 1.7 when compared to the carpet boom overpressure from steady level flight at 1.2 M at 10,000 feet. However, by comparing the maximum overpressure to the carpet boom measured during this pass the amplification factor is around 4. This pass occurred during mild atmospheric turbulent conditions and had provided the best define focus region compared to the other passes. Passes 30 through 33 had distorted focus regions while Pass 35 created a similar series as Pass 36.

Pushover

The final maneuver performed during the study involved a climbout pushover type of profile. The ground track was set parallel to the measurement array by 13,700 feet based on predictions by PCBoom3[10]. Only two passes were performed for this maneuver with the data provided in Table 5. The booms measured from pass 37 are shown in Figure 16. The maximum peak overpressure was 11.6 psf and occurred 2,000 feet downtrack of the target point. This booms was amplified by a factor of 3.4 when compared to a 3.4 psf overpressure from steady level flight at 1.2 Mach at 14,000 feet. For this series only slight disturbances appear to trail behind the N wave in the post-focus region and the focus region is very narrow. Pass 38 did not have as well of defined focused region since the maximum peak overpressure was only 5.8 psf. The results demonstrate that the focus region occurs lateral to the flight track centerline for this maneuver which is important for supersonic civil transports to consider as the aircraft levels off during cruise.

CONCLUSIONS

This paper summarizes the basic data collected for a controlled focus boom study completed in April 1994 at Edwards AFB CA, USA. The objectives of this study were to test the ability of aircrews to control the placement of focus booms with preplanned supersonic maneuvers, to validate prediction methods, and to measure the effect of turbulent conditions on the focusing of the sonic booms produced by these maneuvers. Of the 49 flights 37 focus booms were placed within the array. Predictions of focal zone geometry (accounting for both linear ray geometry and nonlinear displacement from the caustic) agree well with measurements. These results are consistent with previous focus sonic boom studies and show that the focus region produced by the four aircraft maneuvers have an width varying from 100 to 1,000 feet. This study demonstrates the ability of aircrews to control the focal region of the sonic boom footprints with preplanning of the flight profile. This finding could help in minimizing adverse impacts from

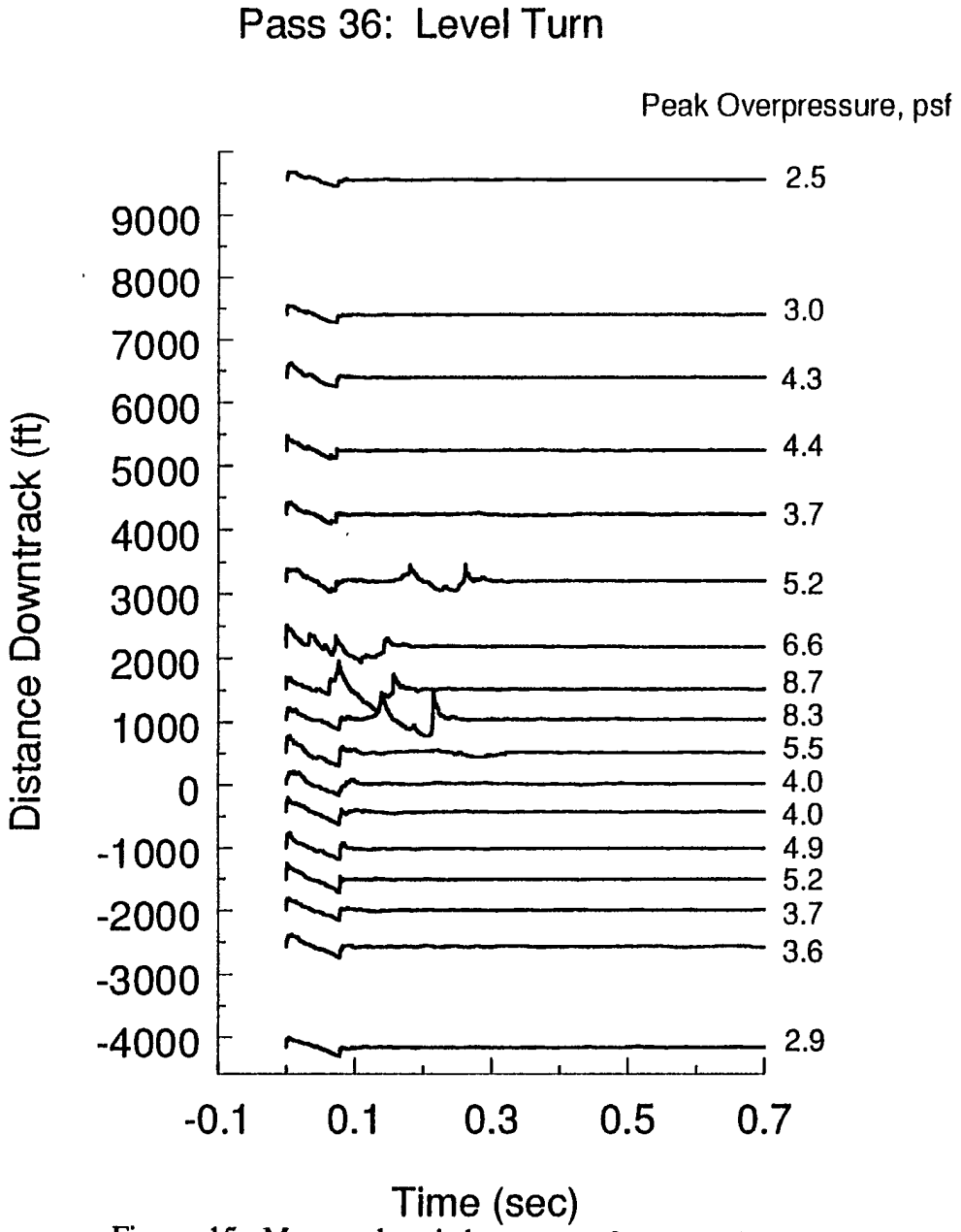


Figure 15. Measured sonic boom waveforms produced by a 4g turn at 1.2 Mach, Pass 36. (Signatures are aligned in time relative to the leading shock.)

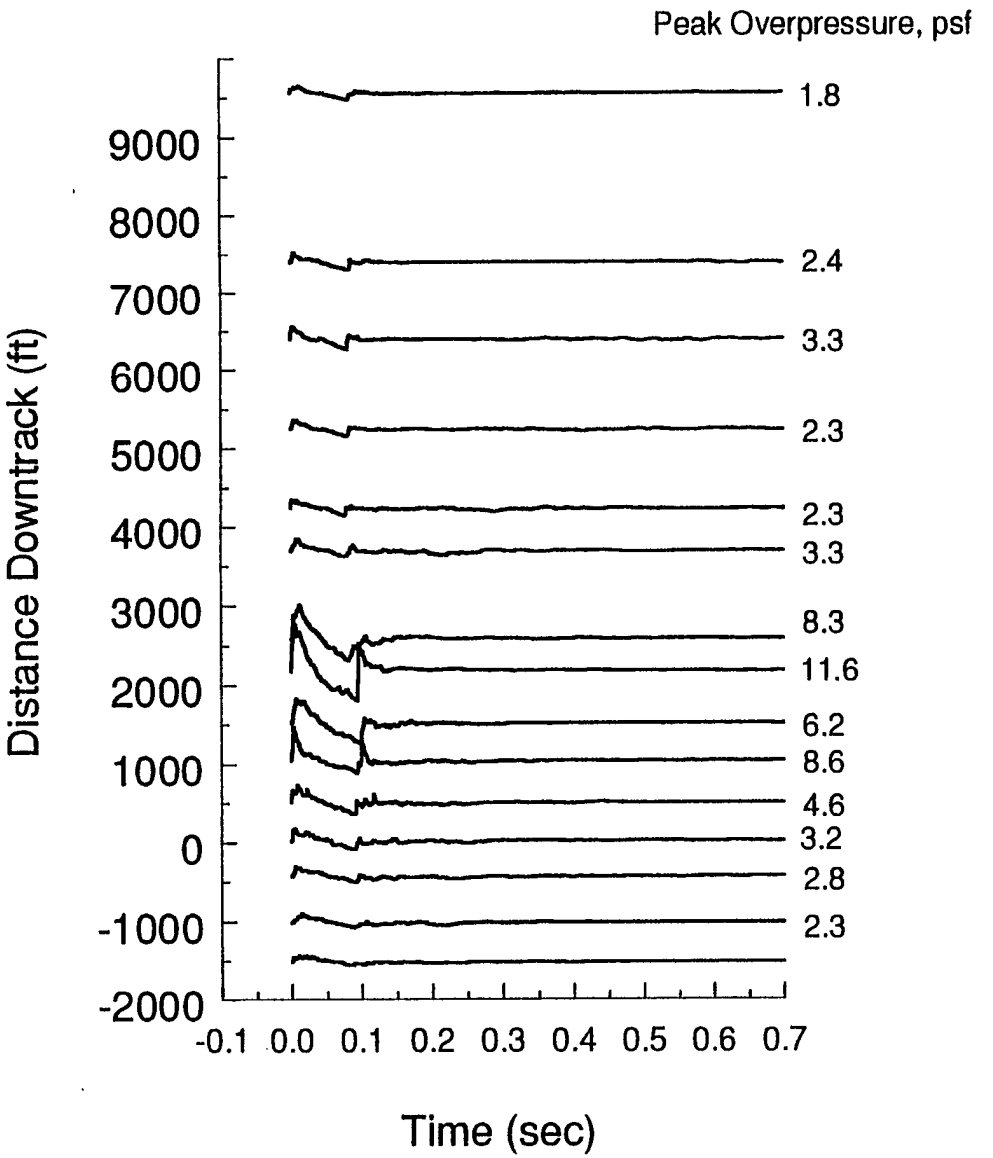


Figure 16. Measured sonic boom waveforms produced by a 0.5g pushover maneuver, Pass 37. (Signatures are aligned in time relative to the leading shock.)

planned supersonic training flights. Also, the results of this study confirm that turbulent conditions can defocus the focal regions as suggested by previous studies. Examples of this effect show that the focus regions can be distorted and/or diminished. One flight under mechanical turbulent conditions displayed two focus regions with reduced amplification of the peak levels, while one flight under thermal turbulent conditions showed that the focus region is almost completely diminished. These two examples demonstrate that turbulence can have a strong defocusing effect on sonic boom propagation.

The 'Have BEARs' sonic boom data along with the tracking and atmospheric data are available in digital format upon request to AL/OEBN, 2610 Seventh Street, Wright-Patterson AFB, OH 45433-7910.

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APPENDIX A: FLIGHT TRACK PLOTS

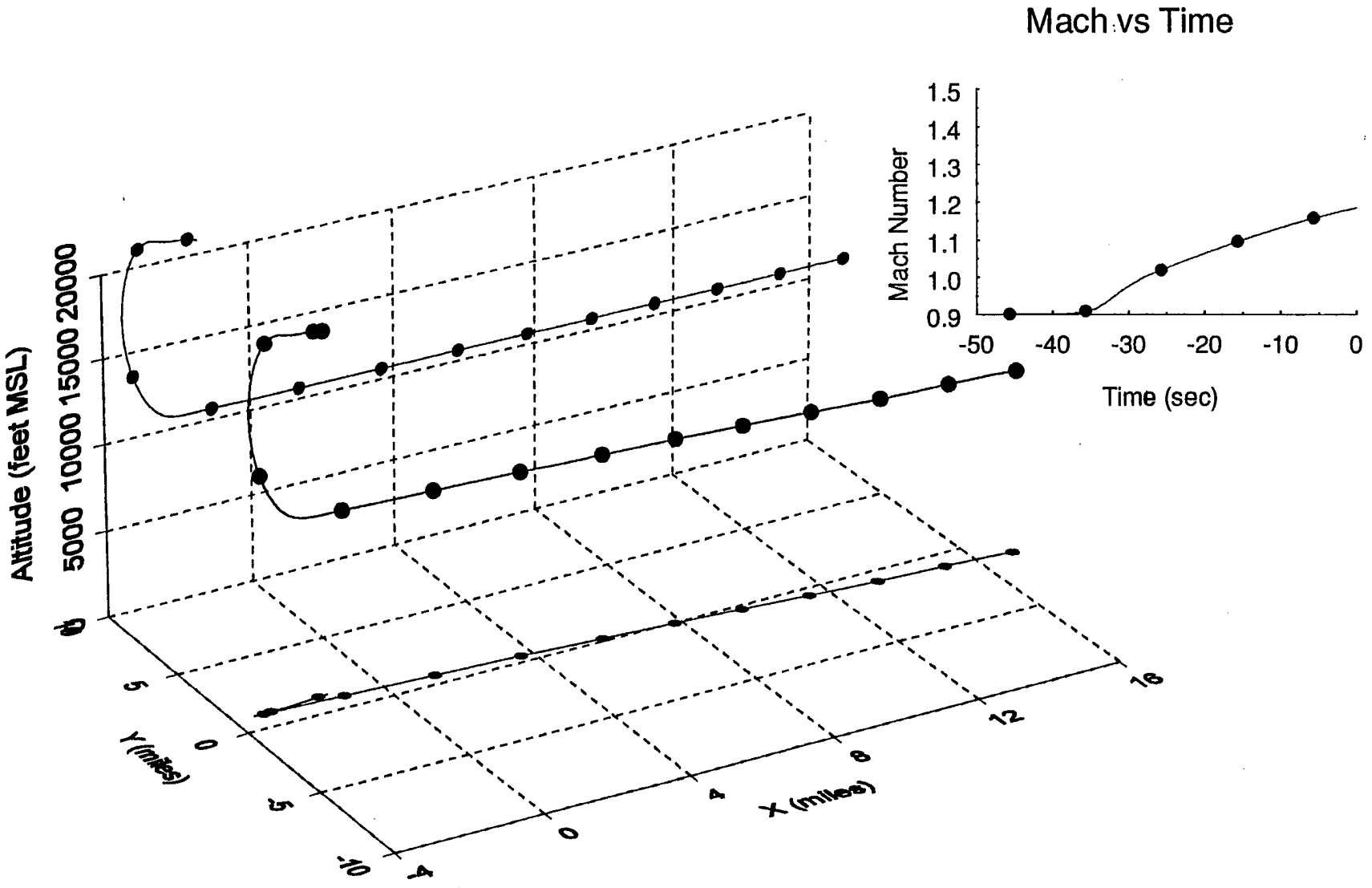

Figure A-1. Flight track for pass 1, level acceleration

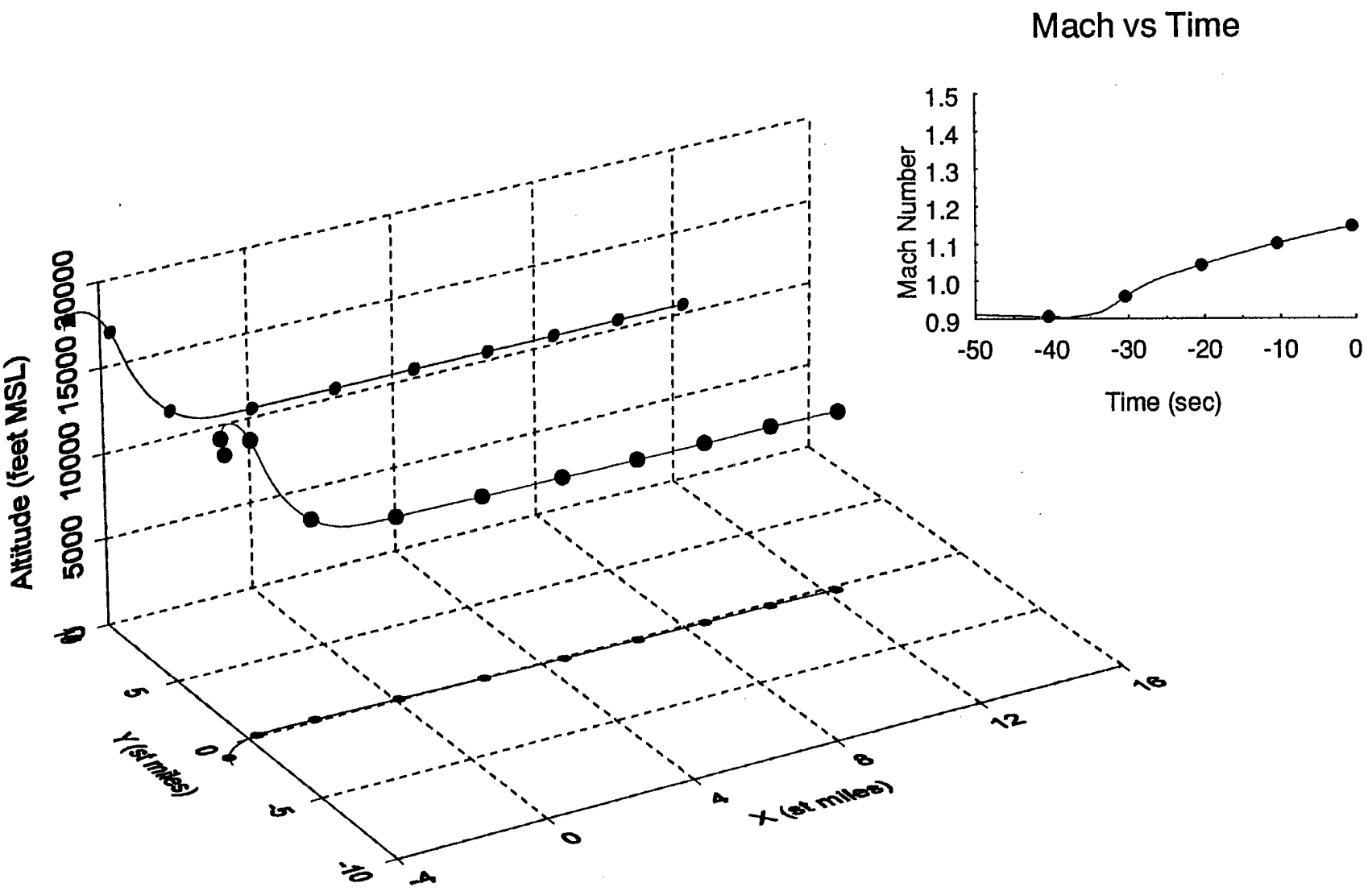

Figure A-2 Flight track for pass 2, level acceleration

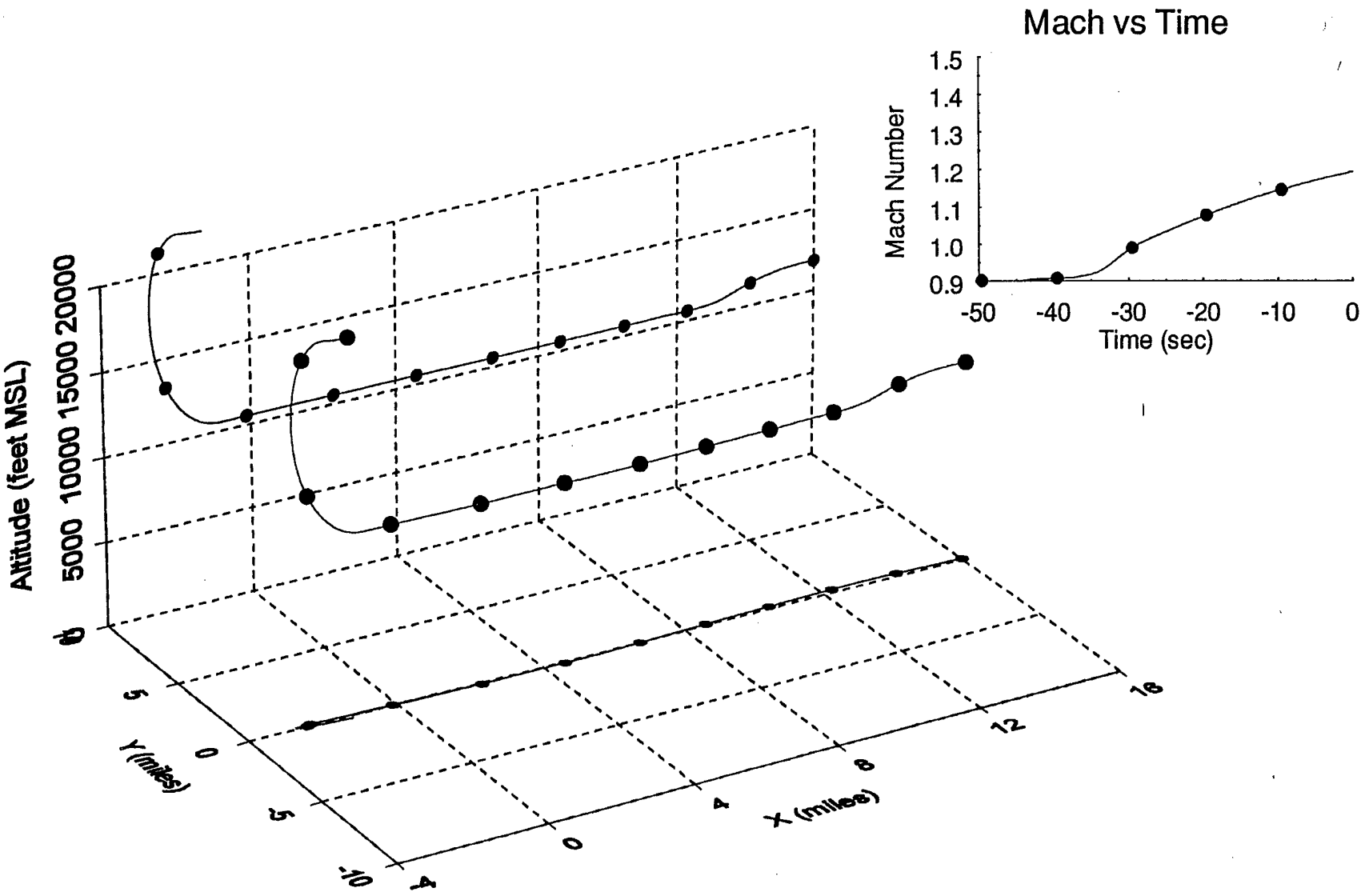

Figure A-3 Flight track for pass 3 level acceleration

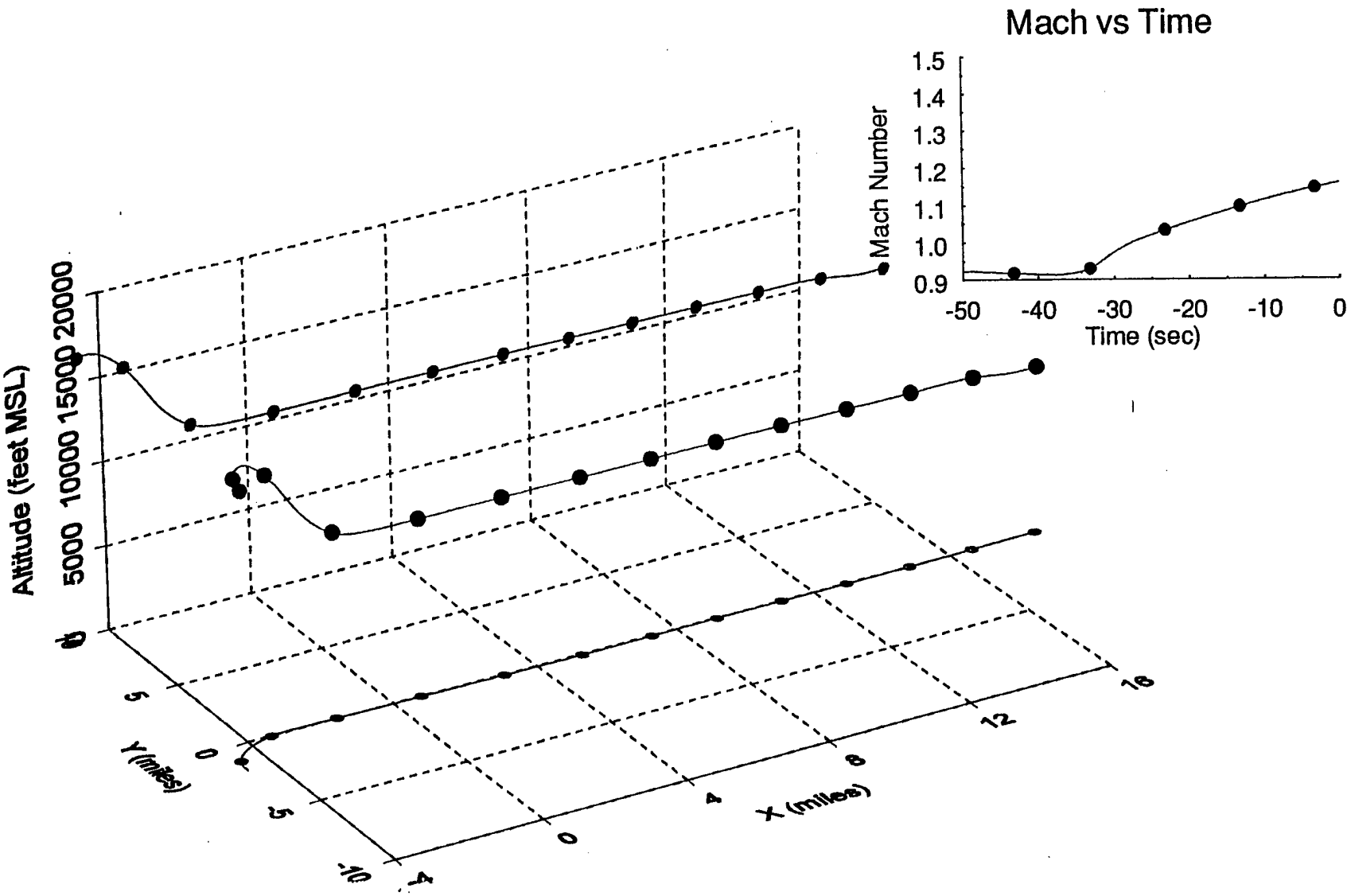

Figure A-4 Flight track for pass 4 level acceleration

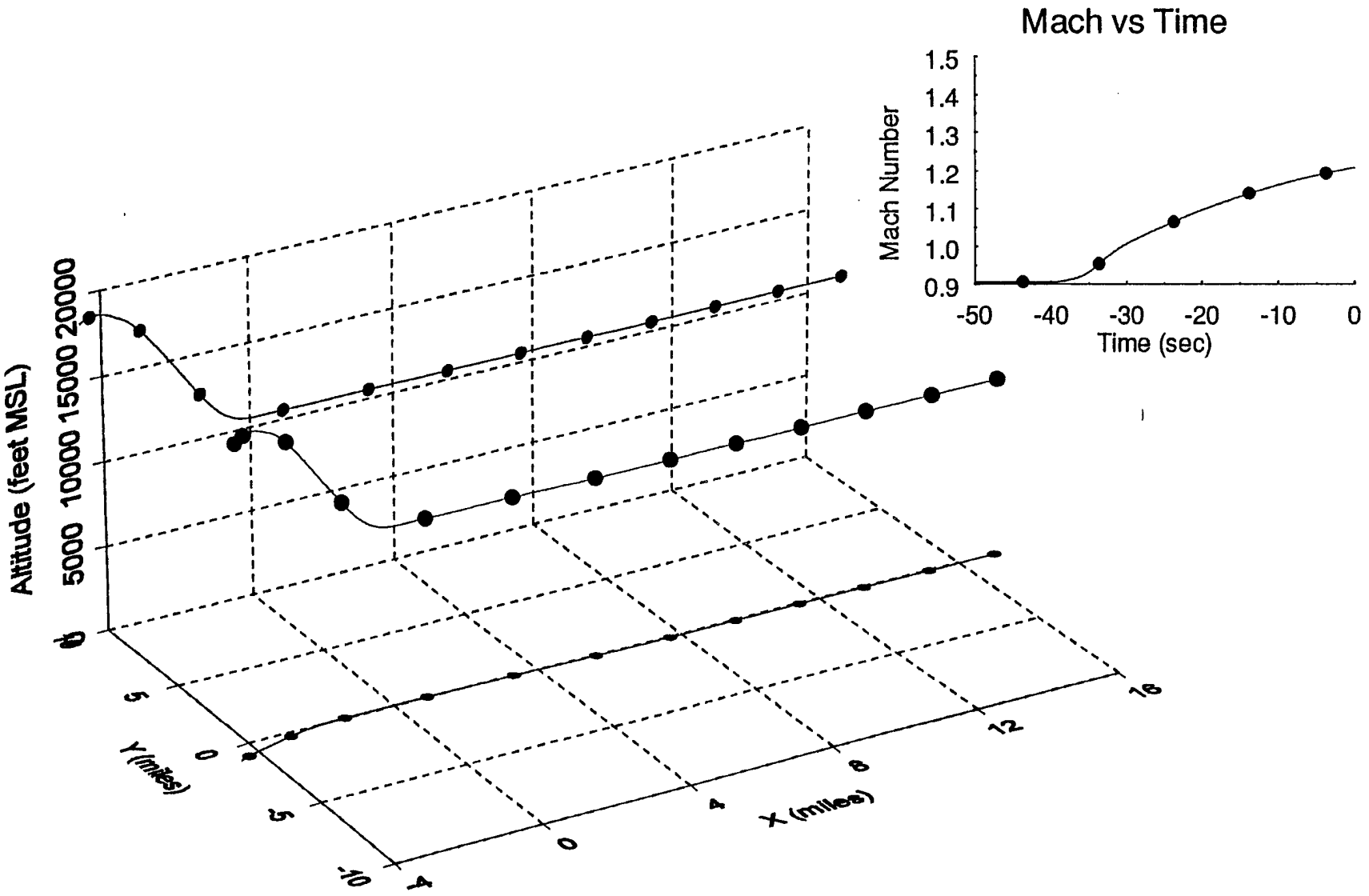

Figure A-5 Flight track for pass 5 level acceleration

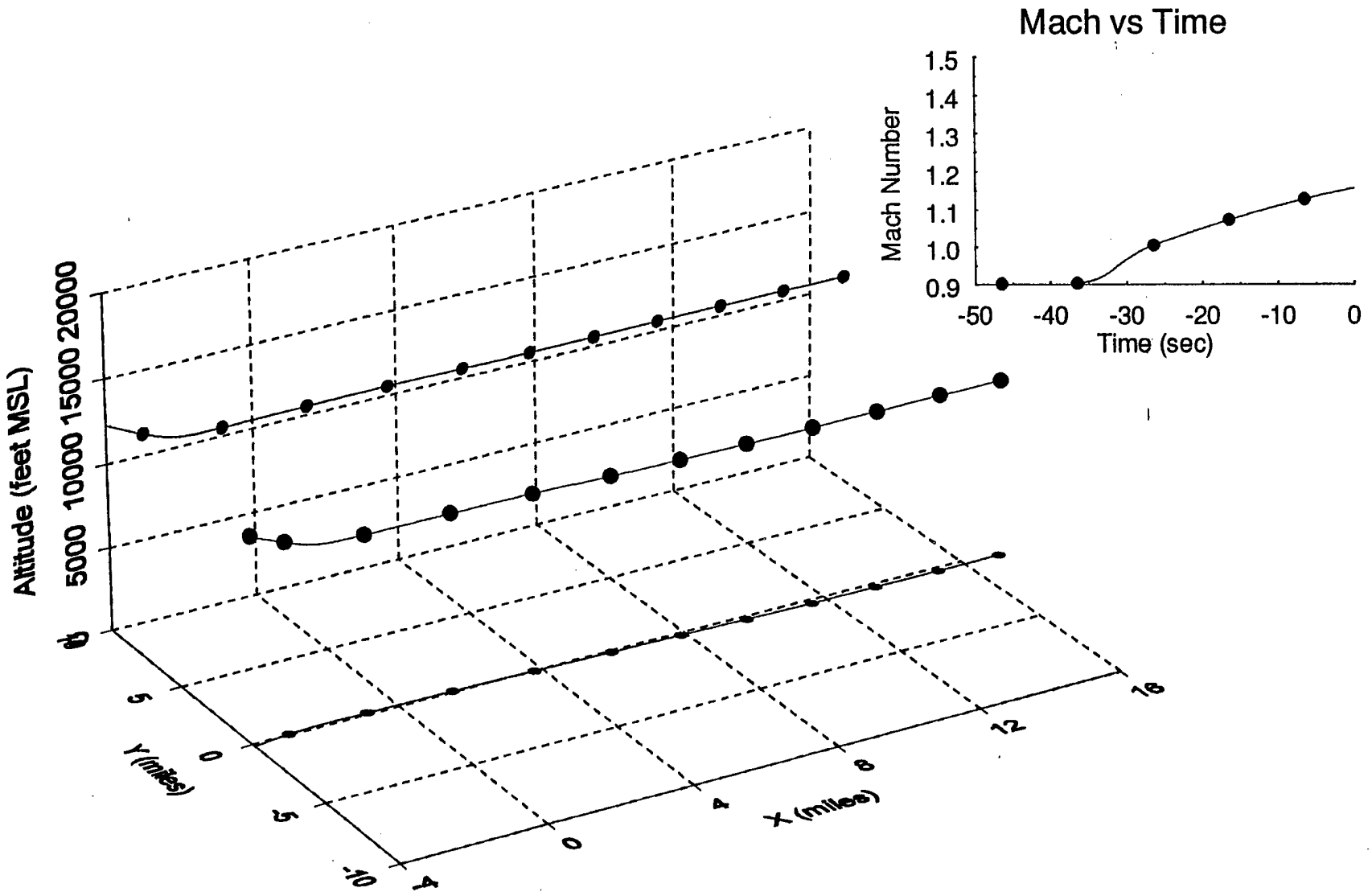

Figure A-6 Flight track for pass 6 level acceleration

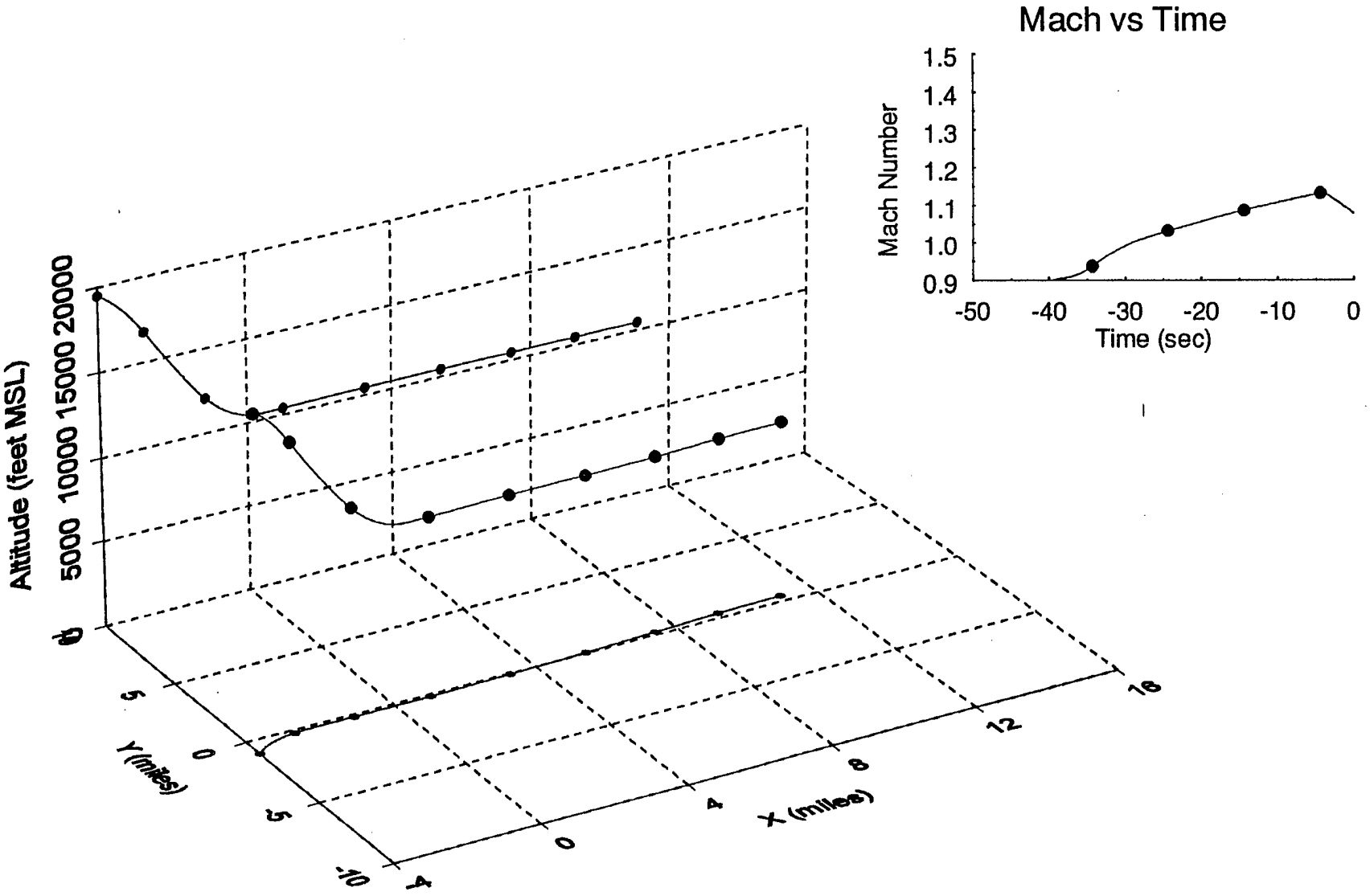

Figure A-7 Flight track for pass 7 level acceleration

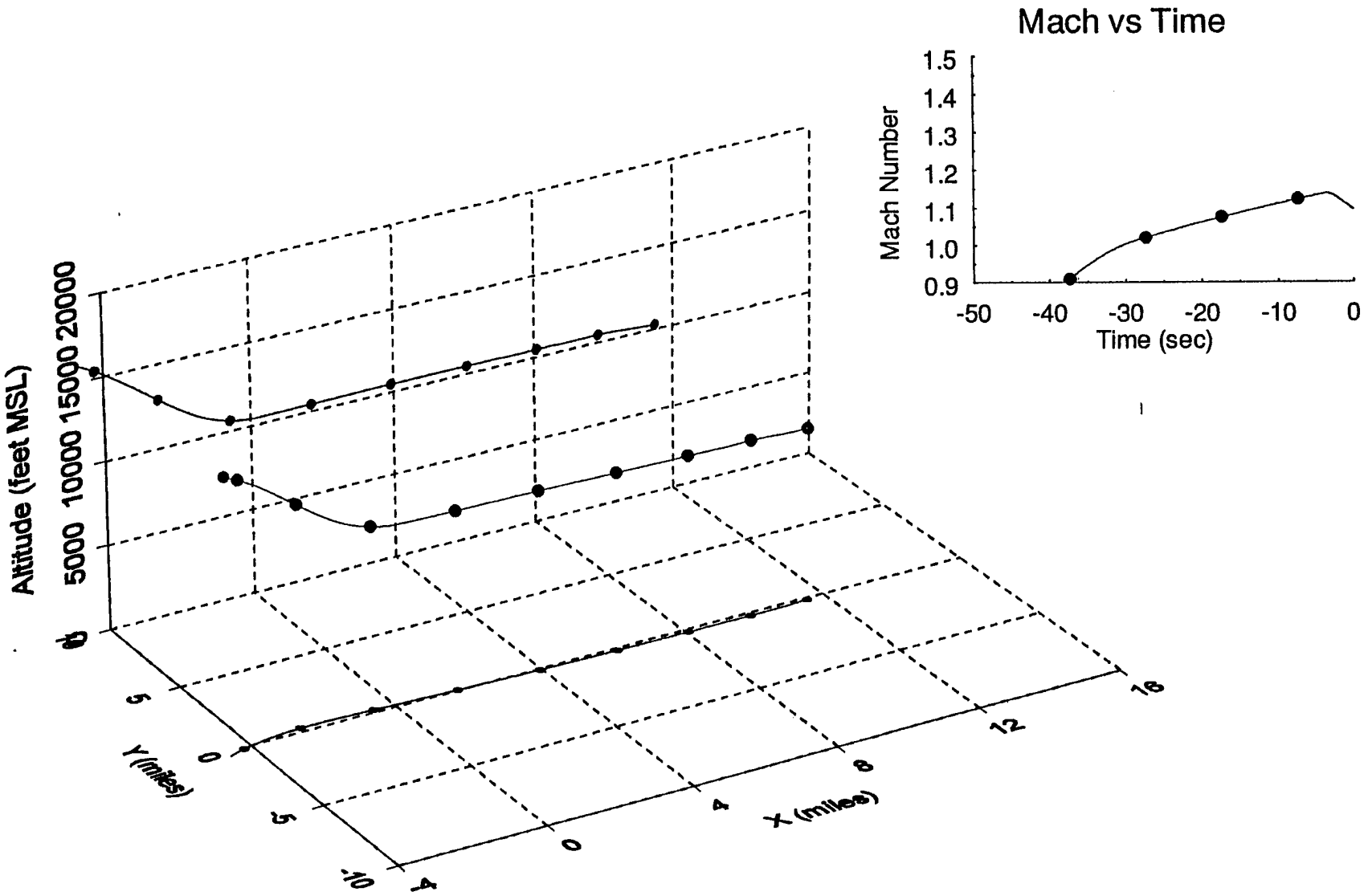

Figure A-8 Flight track for pass 8 level acceleration

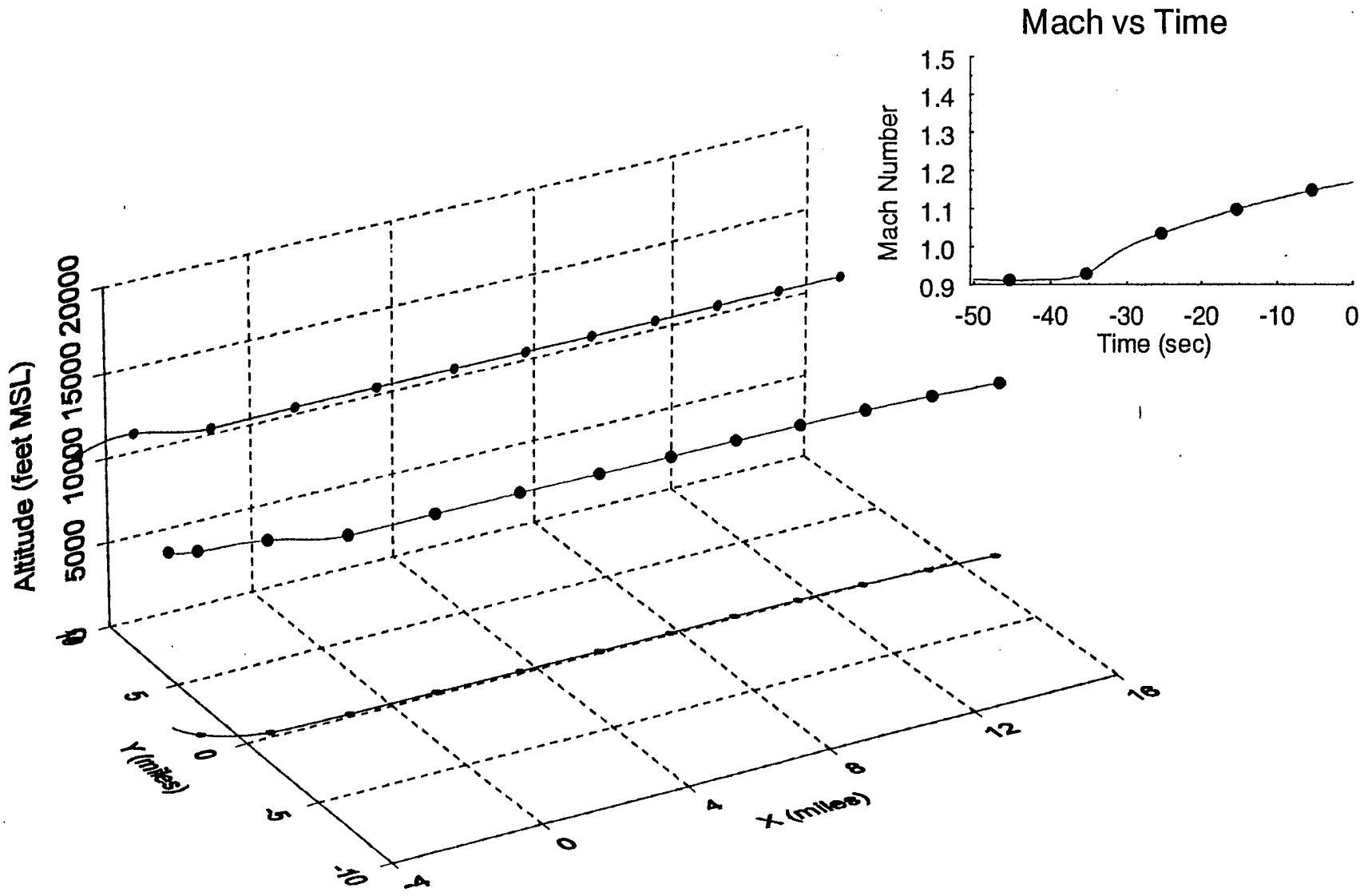

Figure A-9 Flight track for pass 9level acceleration

hb10trk

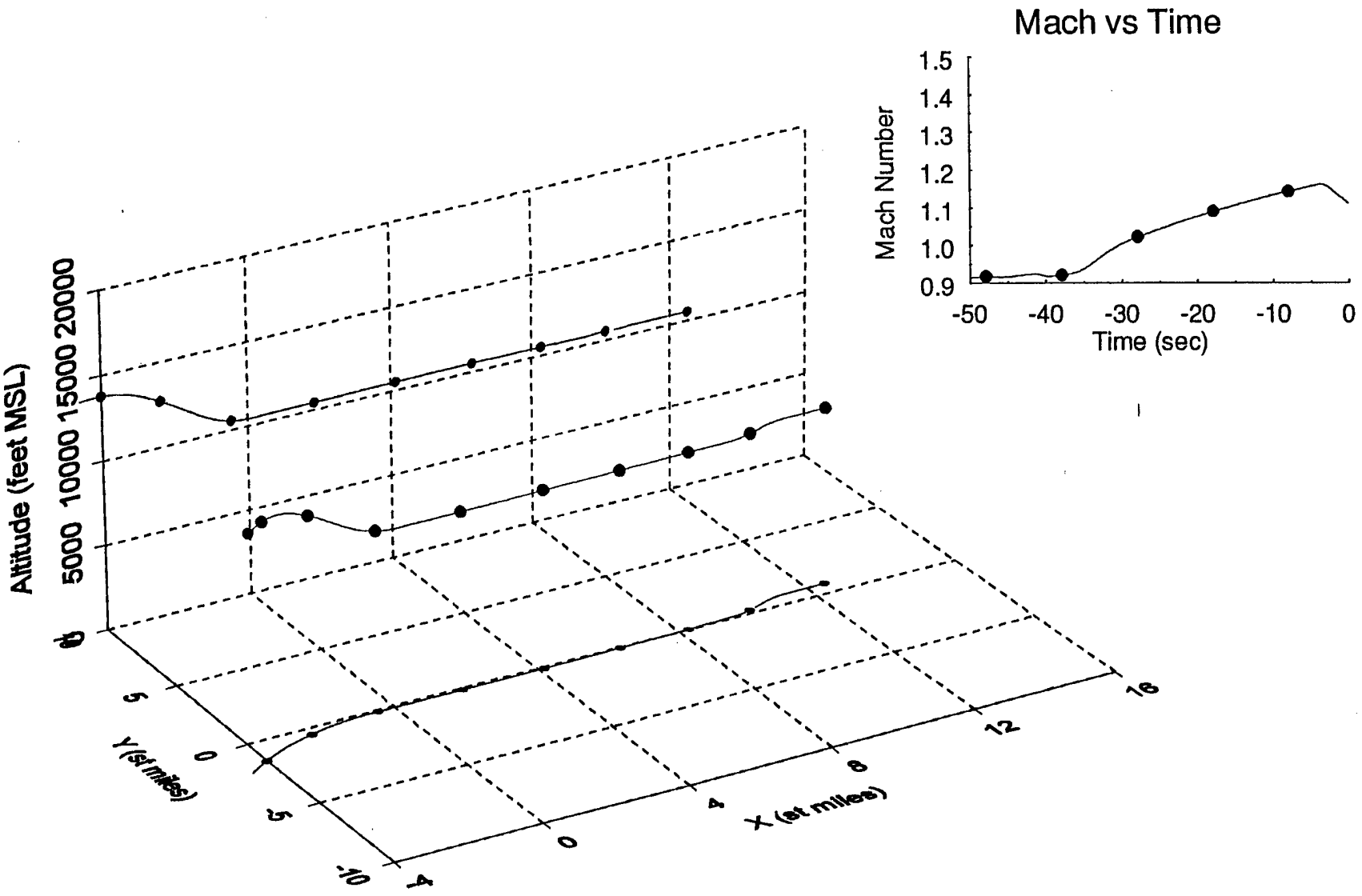

Figure A-10 Flight track for pass 10, level acceleration

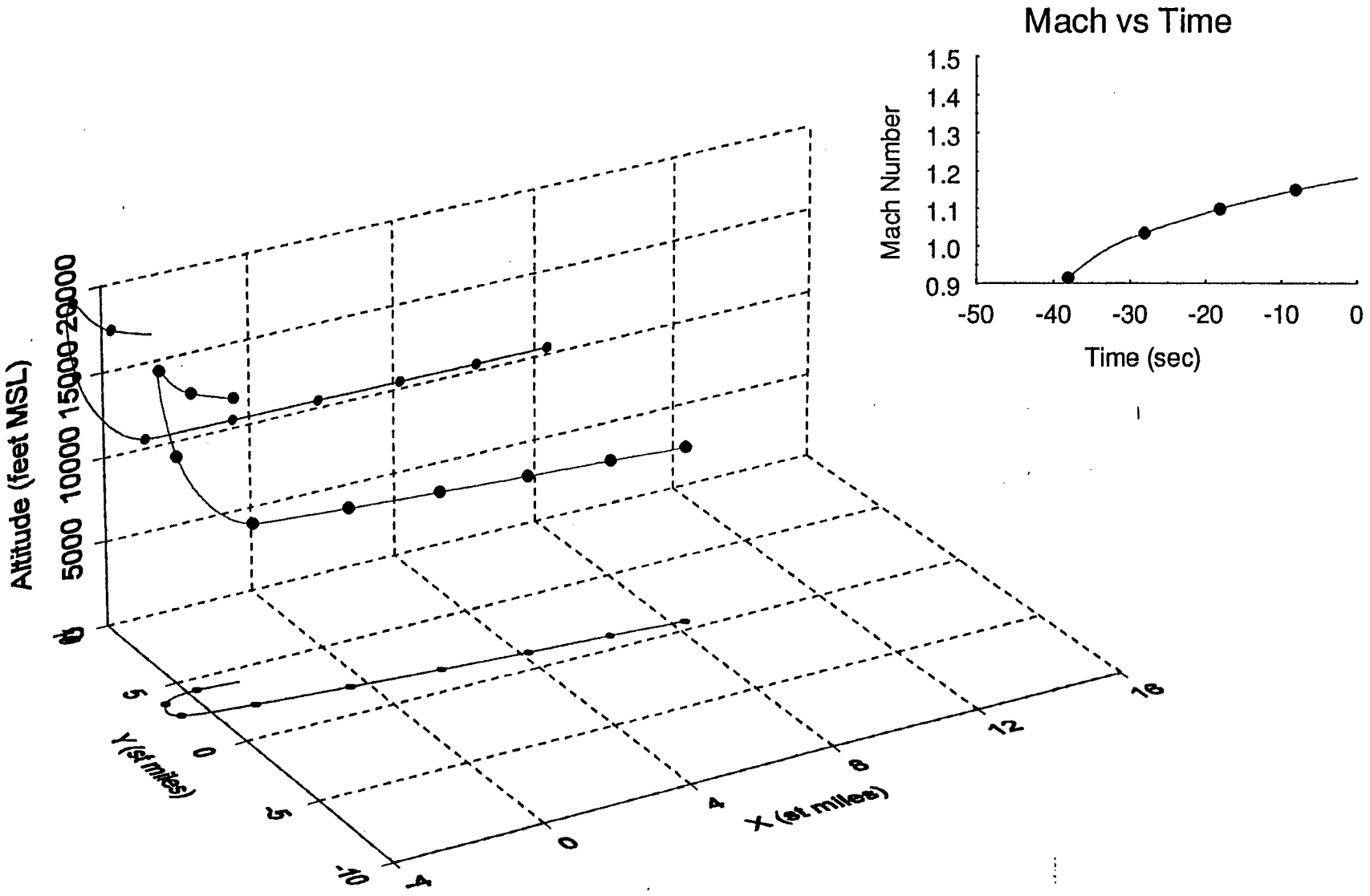

Figure A-11 Flight track for pass 11, level acceleration

hb12trk

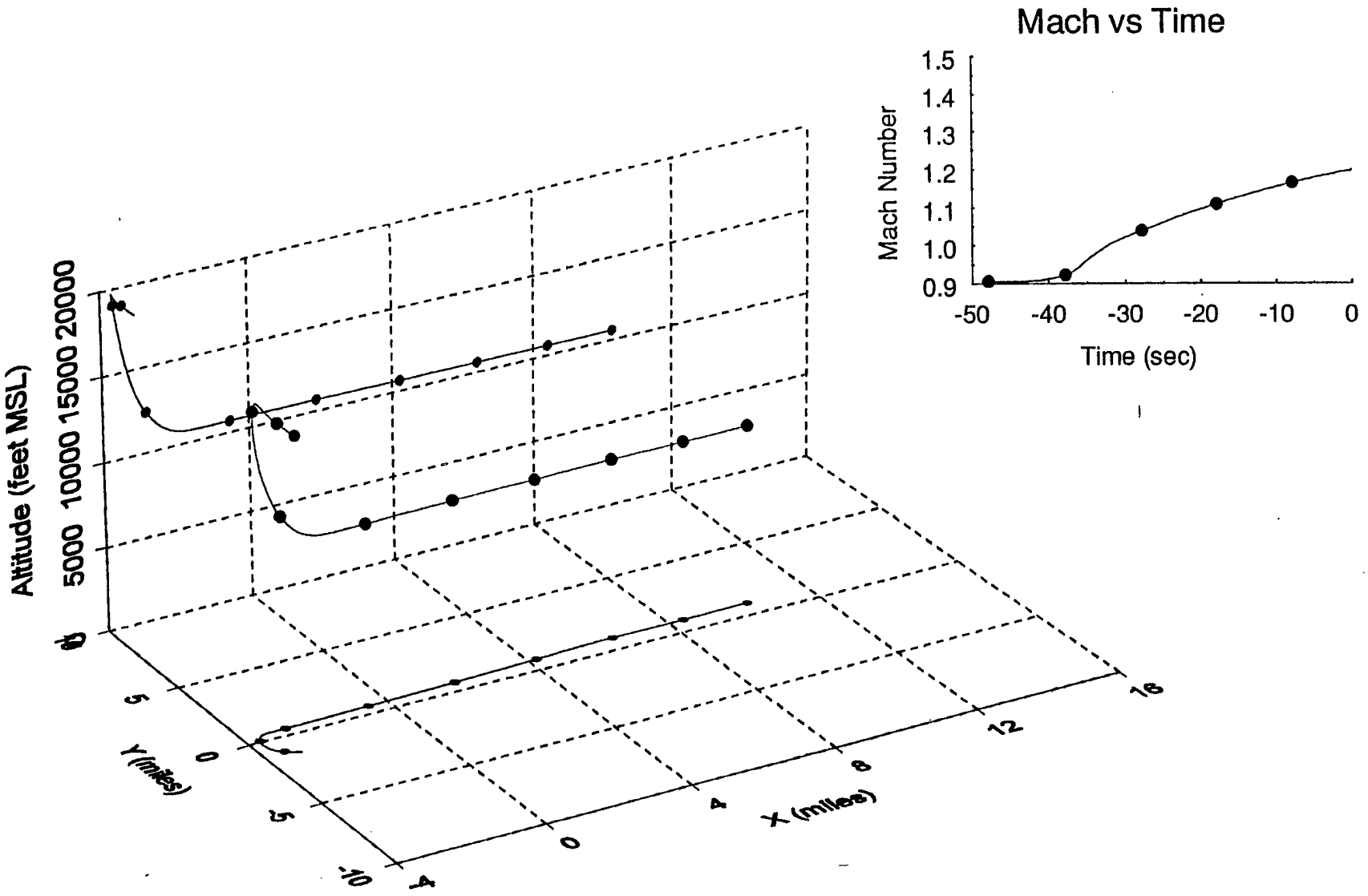

Figure A-12 Flight track for pass 12, level acceleration

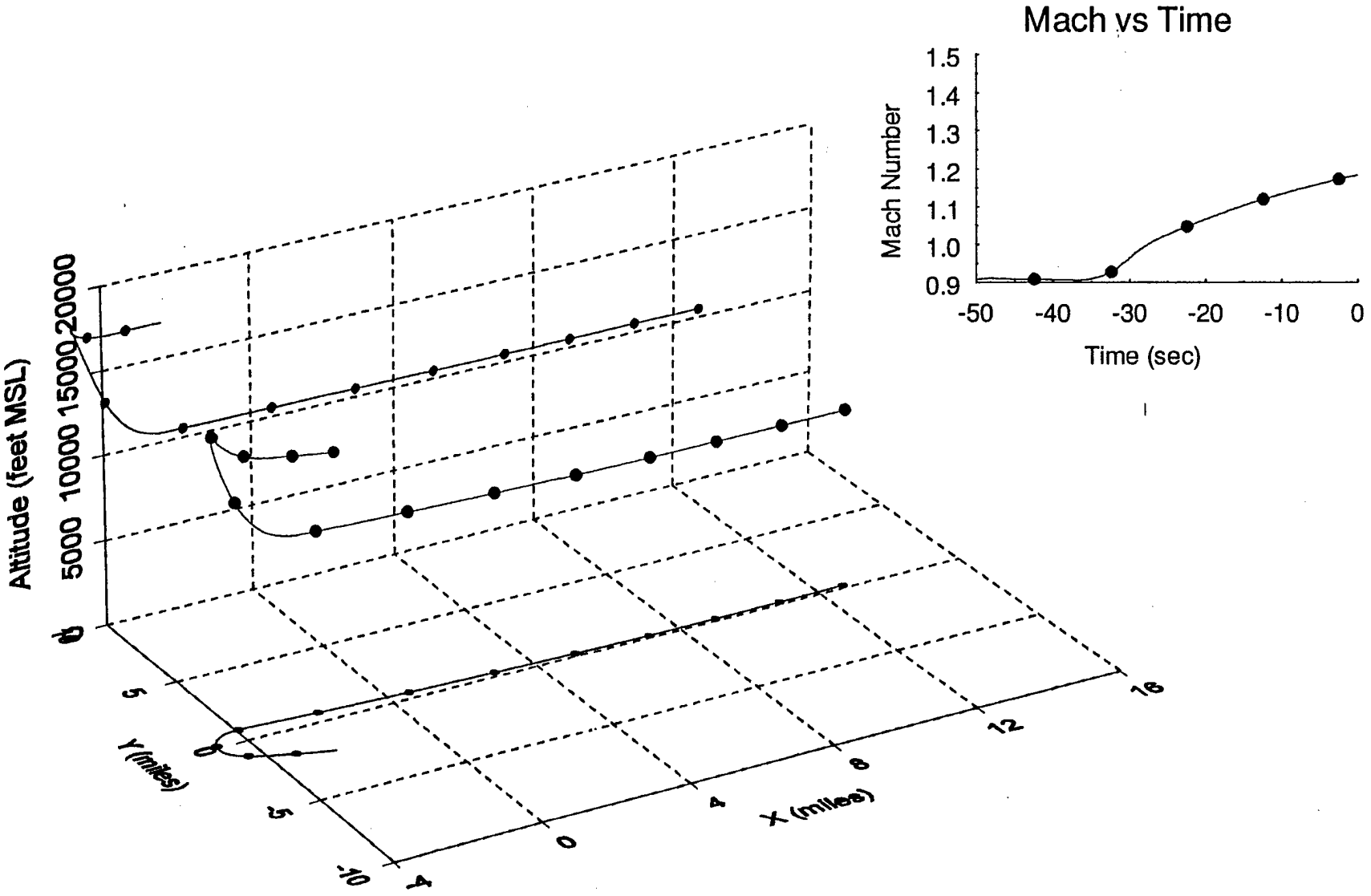

Figure A-13 Flight track for pass 13, level acceleration

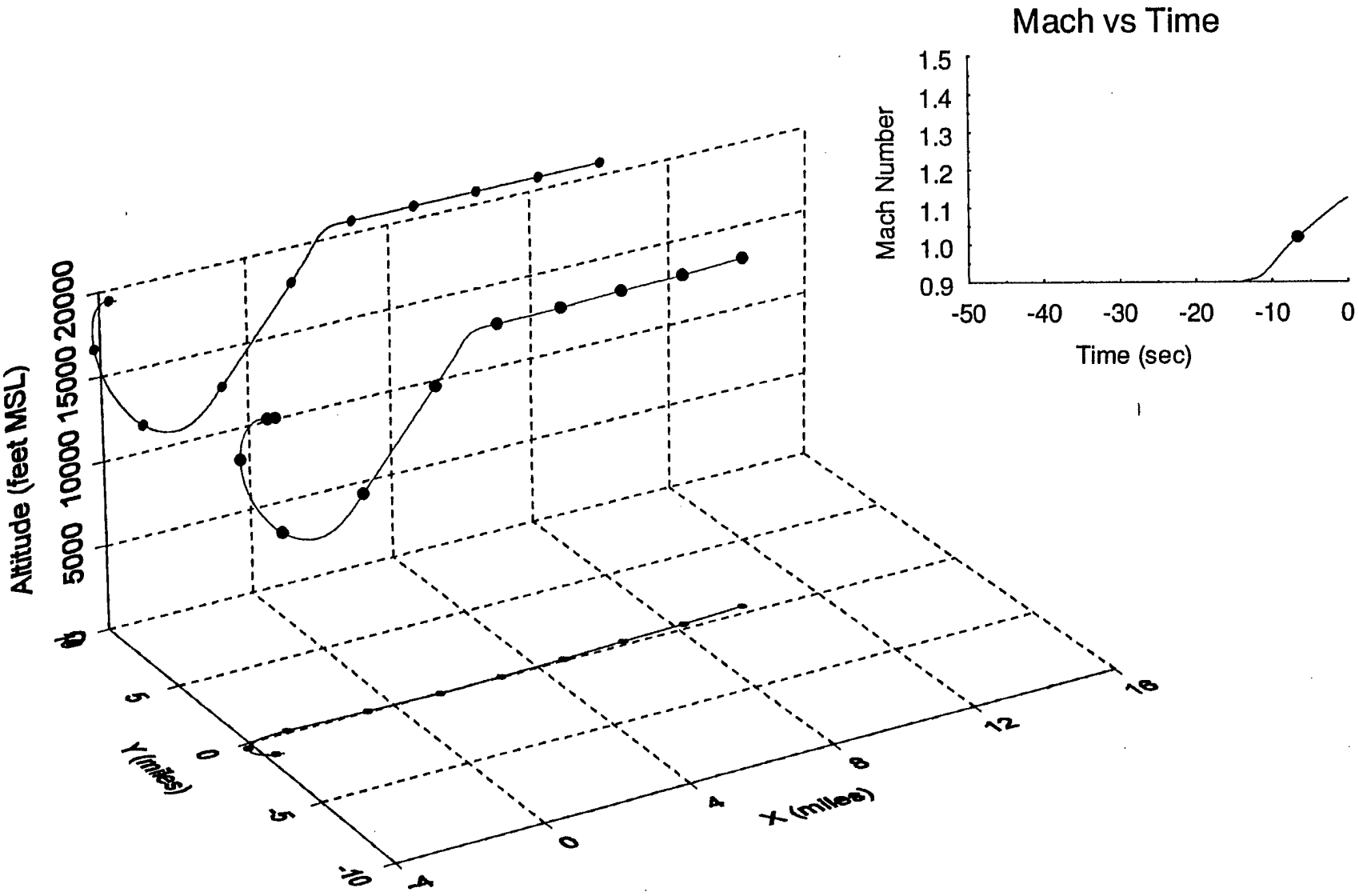

Figure A-14 Flight track for pass 14, 30° diving acceleration

hb15trk

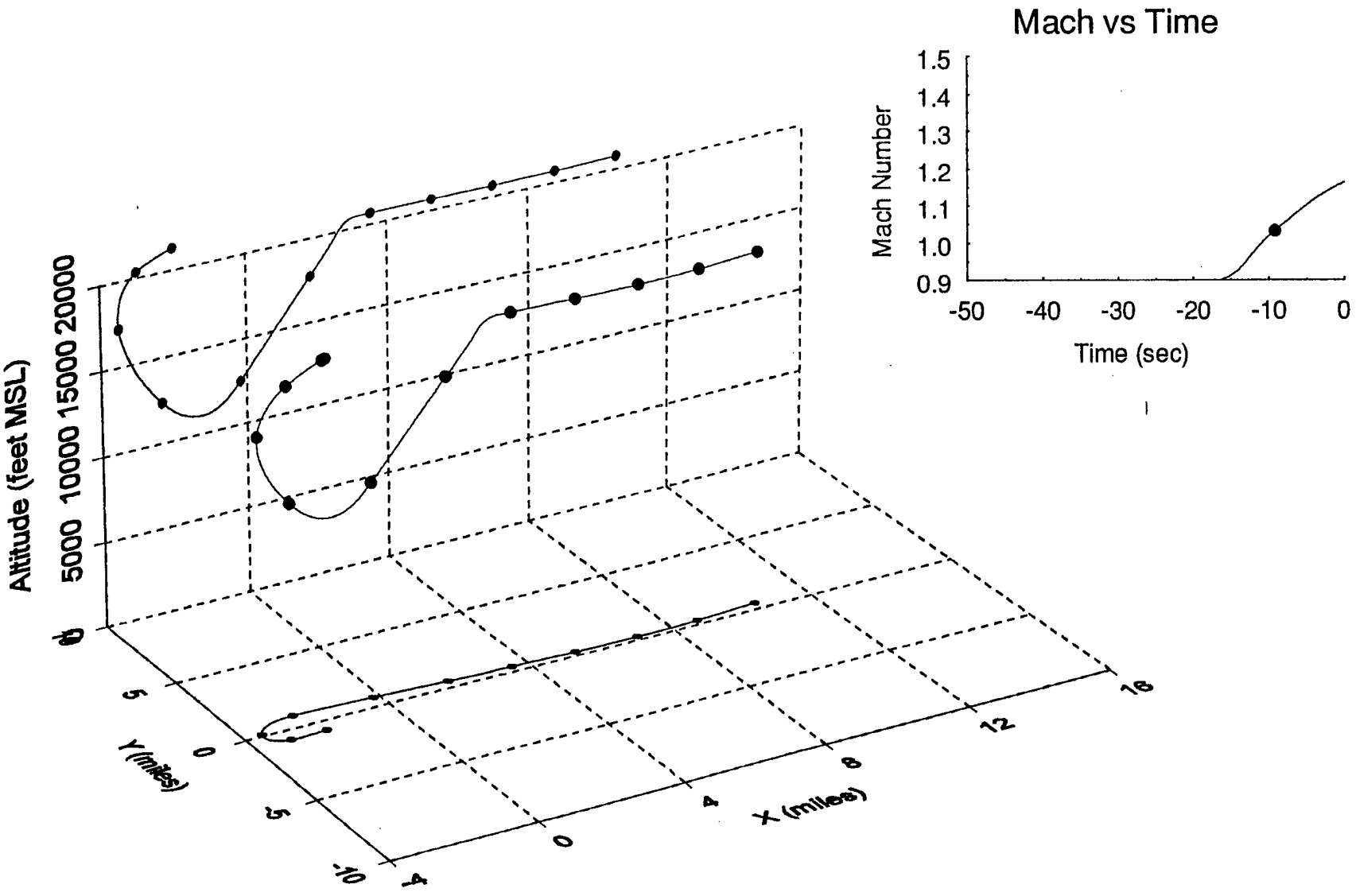

Figure A-15 Flight track for pass 15, 30° diving acceleration

hb16trk

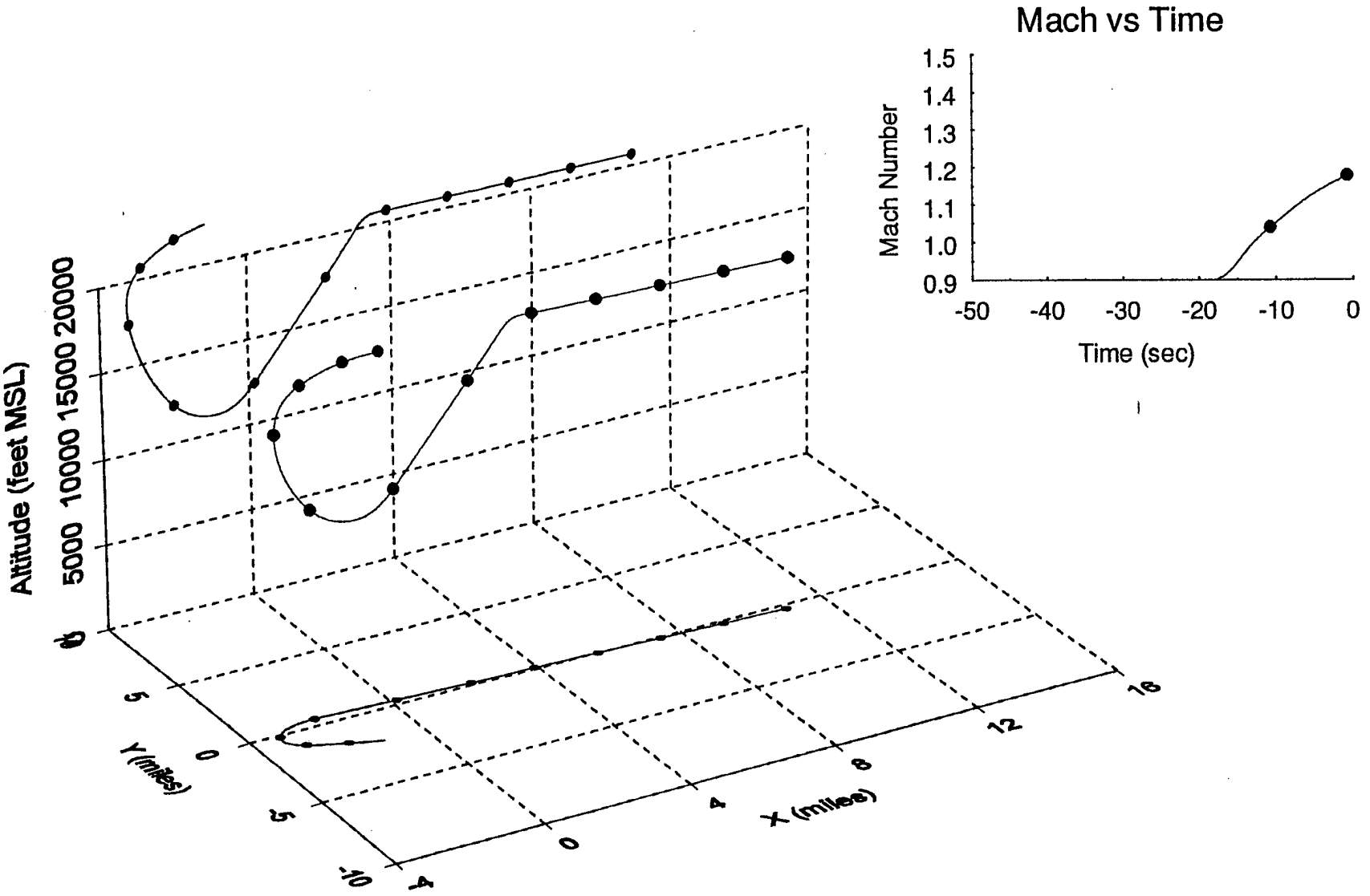

Figure A-16 Flight track for pass 16, 30° diving acceleration

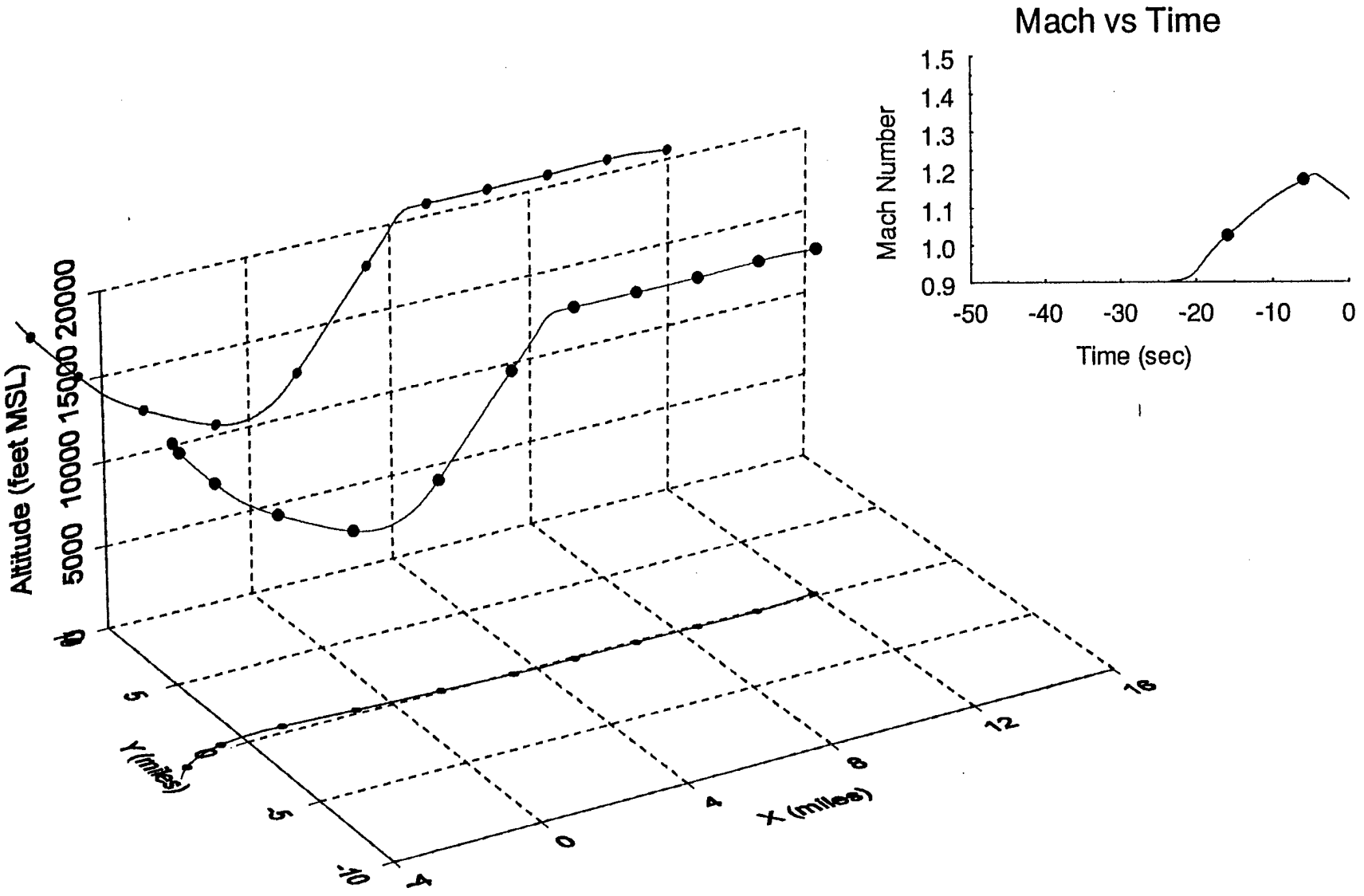

Figure A-17 Flight track for pass 17, 30° diving acceleration

PASS 18: NO FLIGHT TRACK DATA AVAILABLE

Figure A-18 Flight track for pass 18, 30° diving acceleration

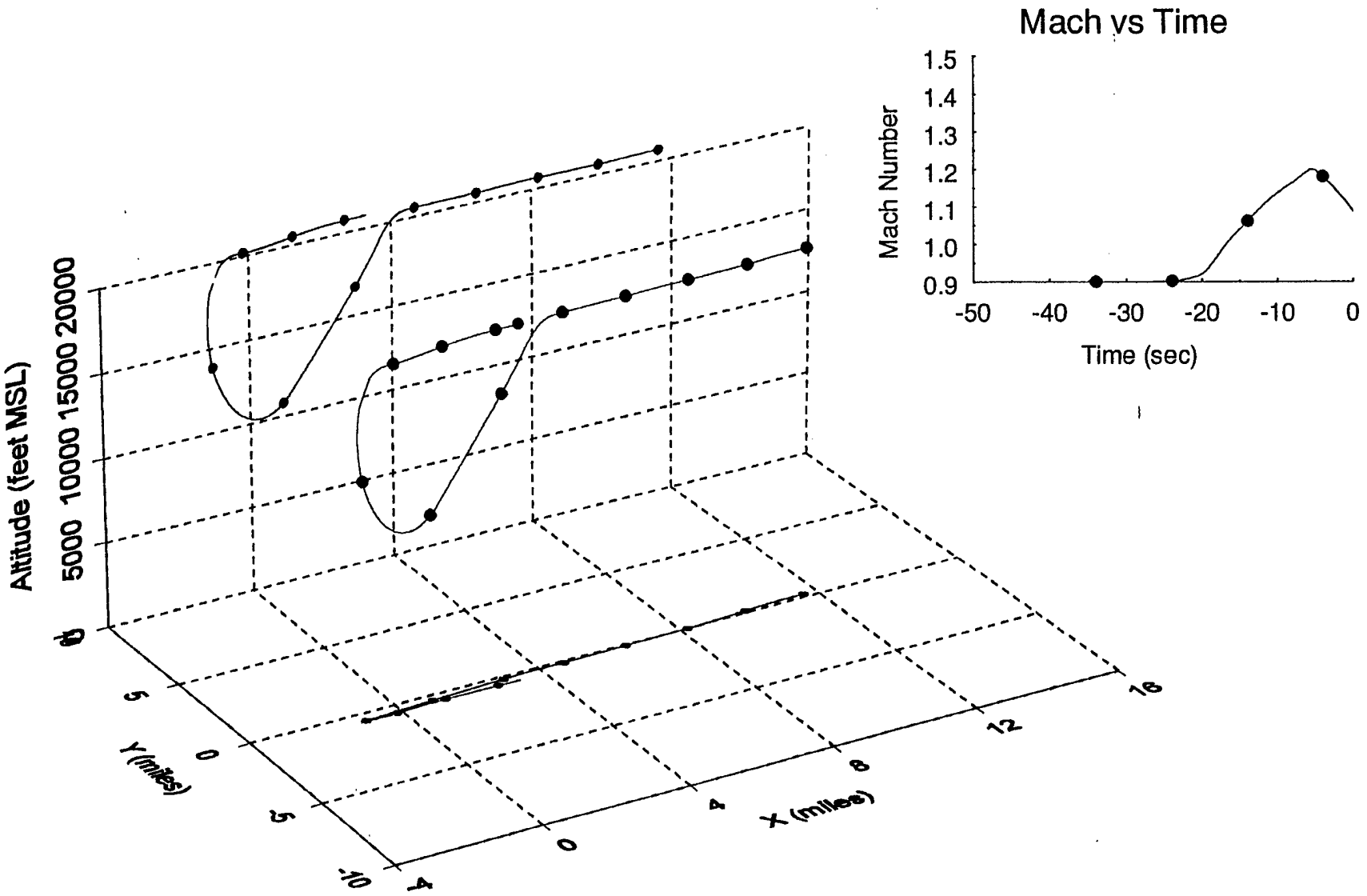

Figure A-19 Flight track for pass 19, 30° diving acceleration

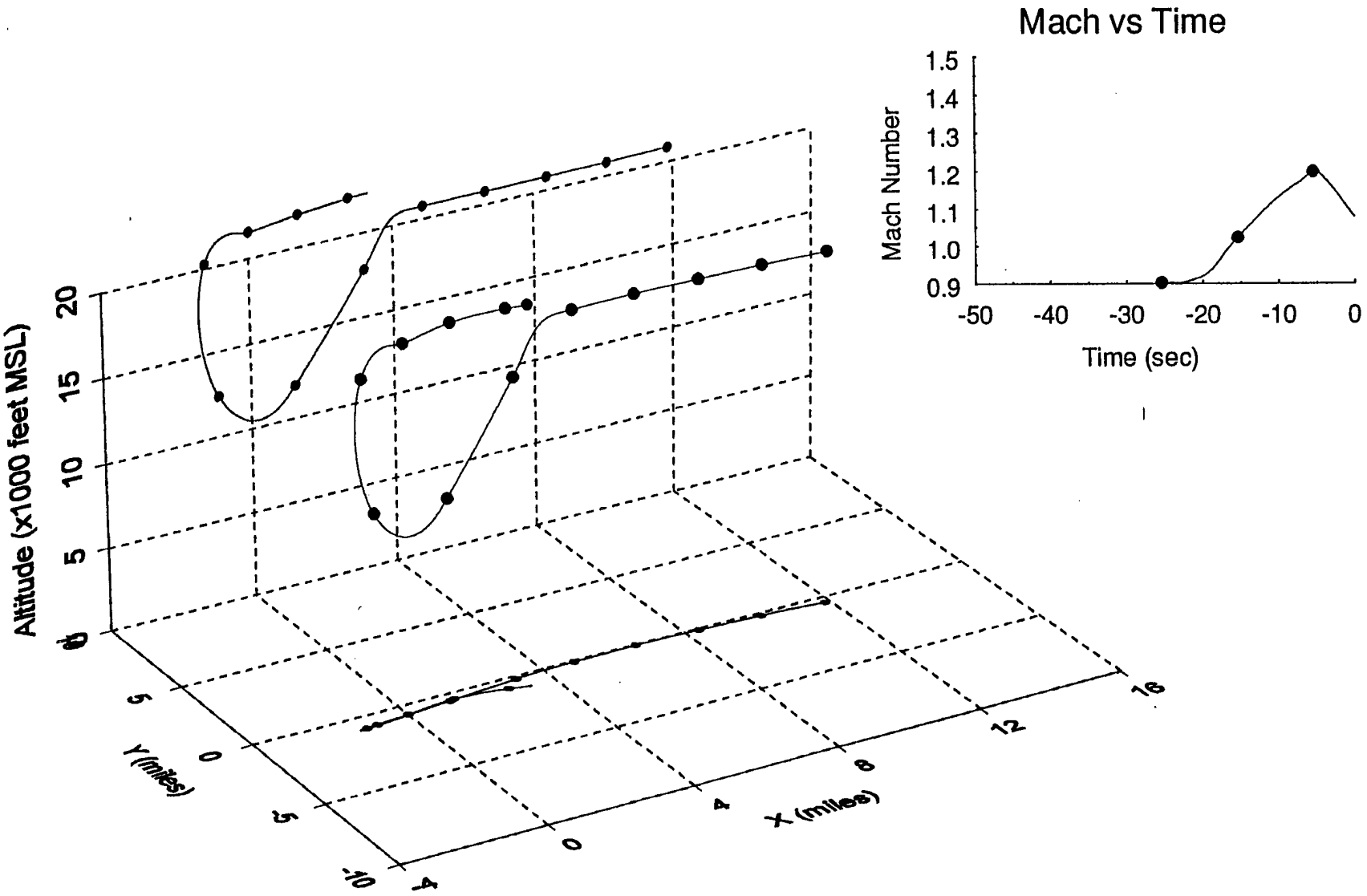

Figure A-20 Flight track for pass 20, 30° diving acceleration

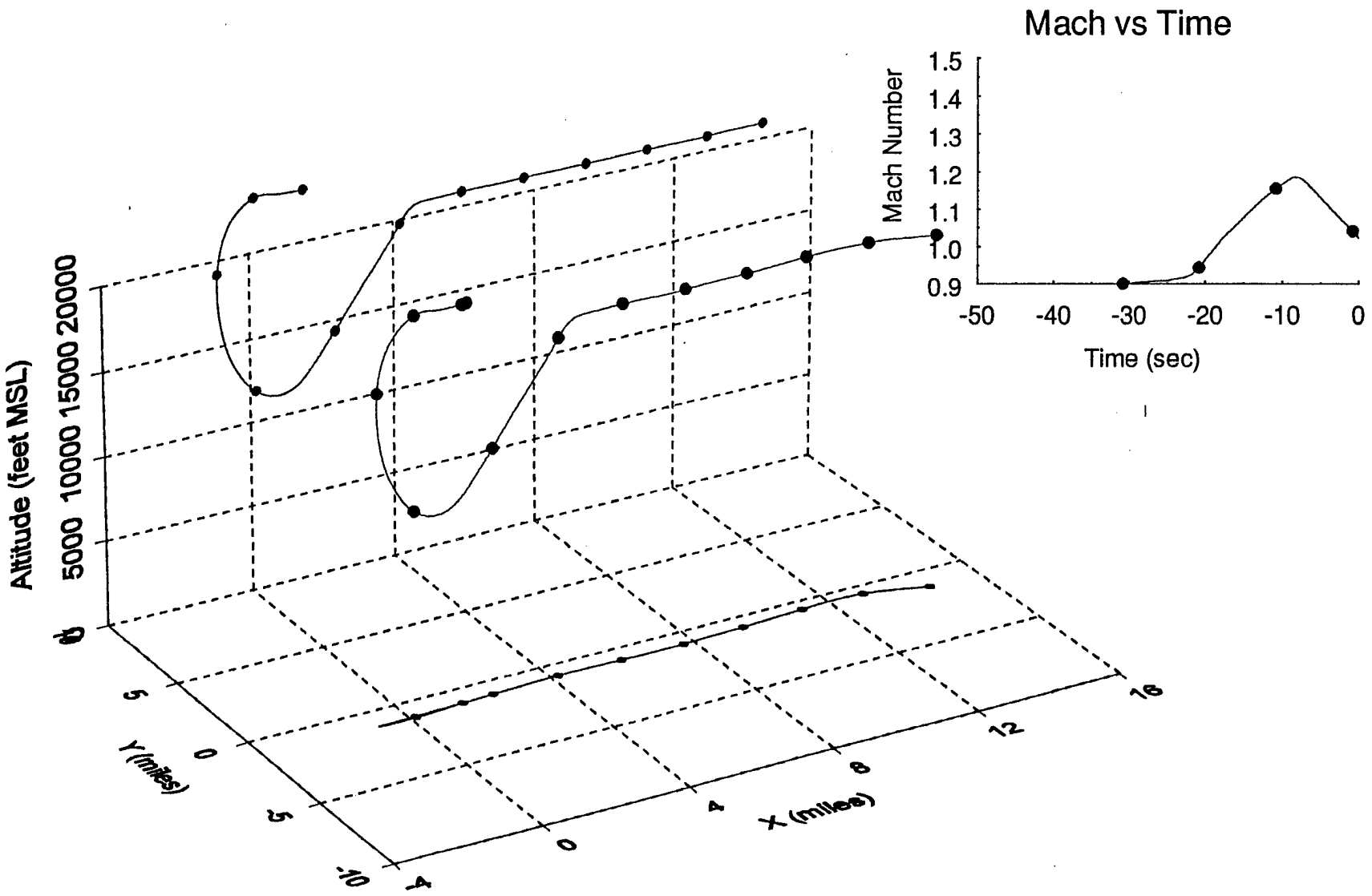

Figure A-21 Flight track for pass 21, 30° diving acceleration

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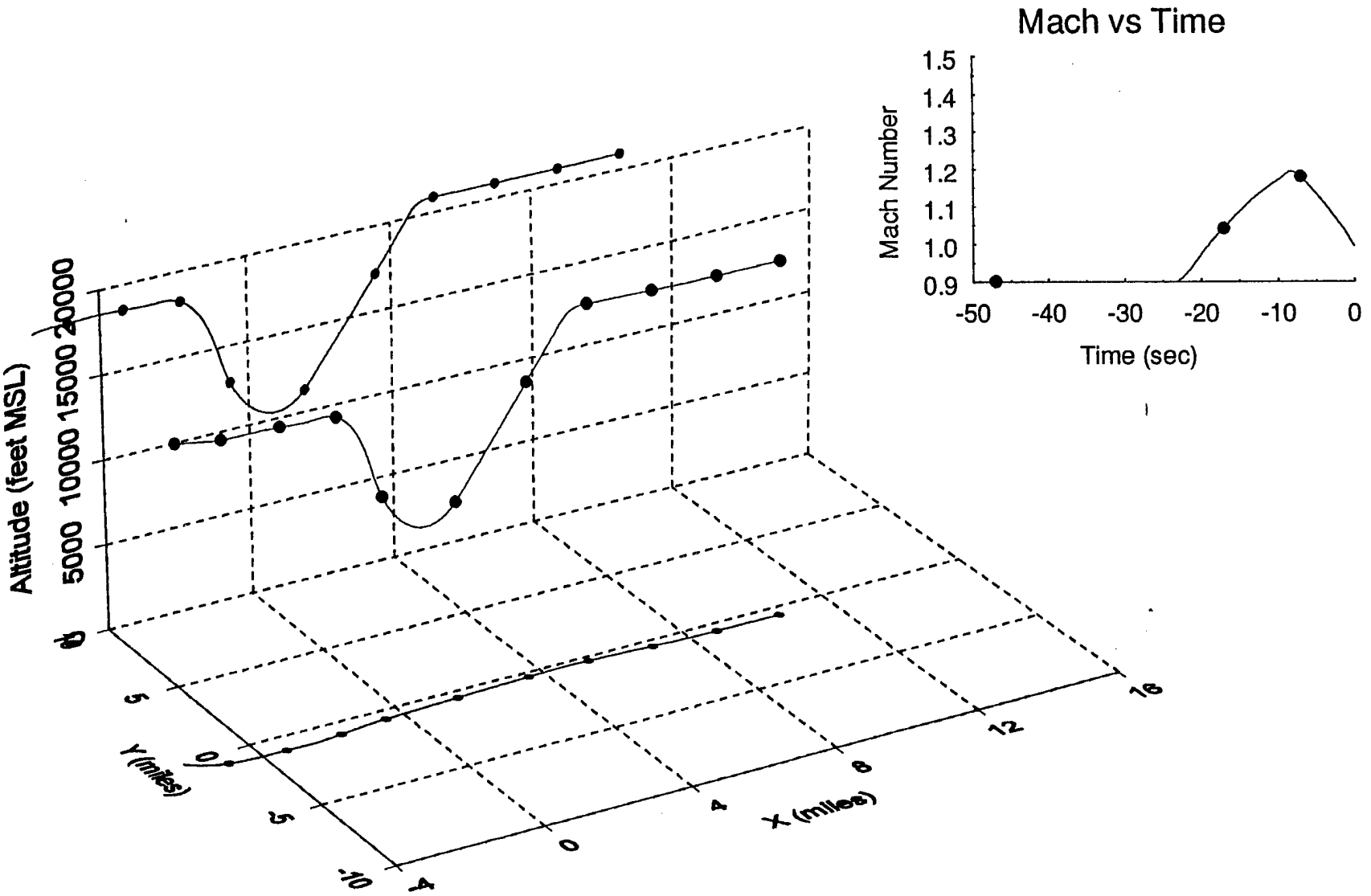

Figure A-22 Flight track for pass 22, 30° diving acceleration

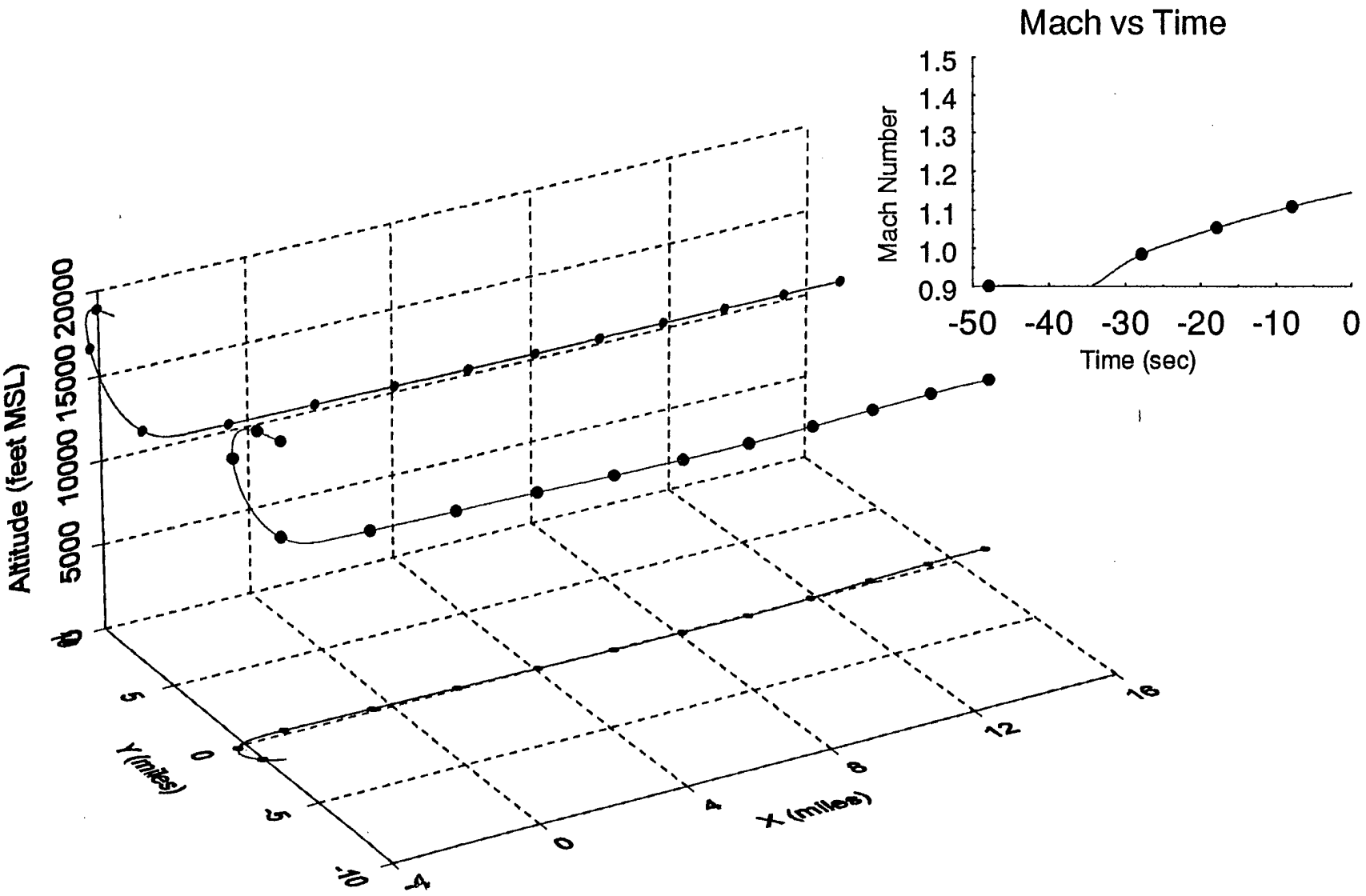

Figure A-23 Flight track for pass 23, level acceleration

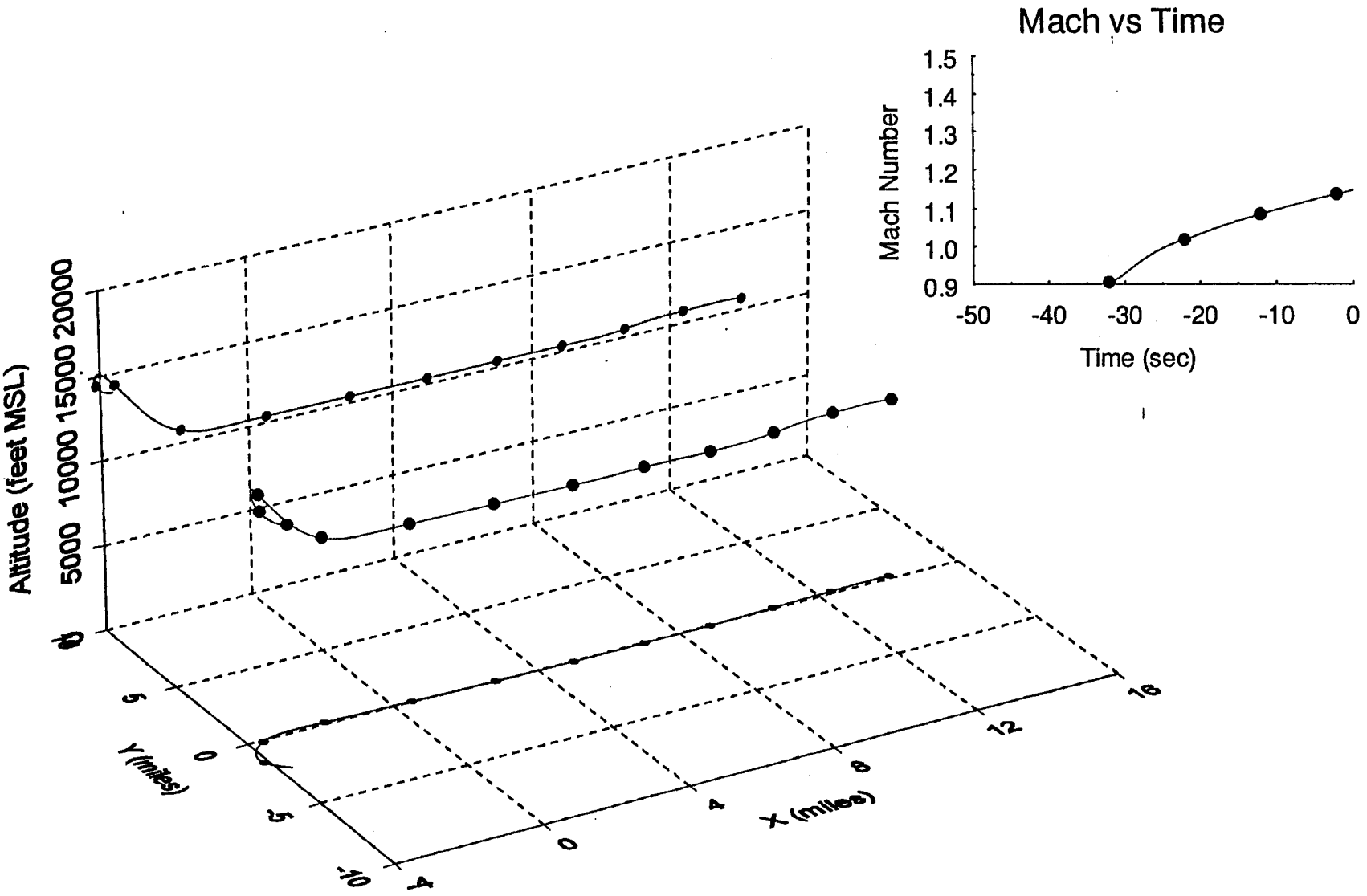

Figure A-24 Flight track for pass 24, level acceleration

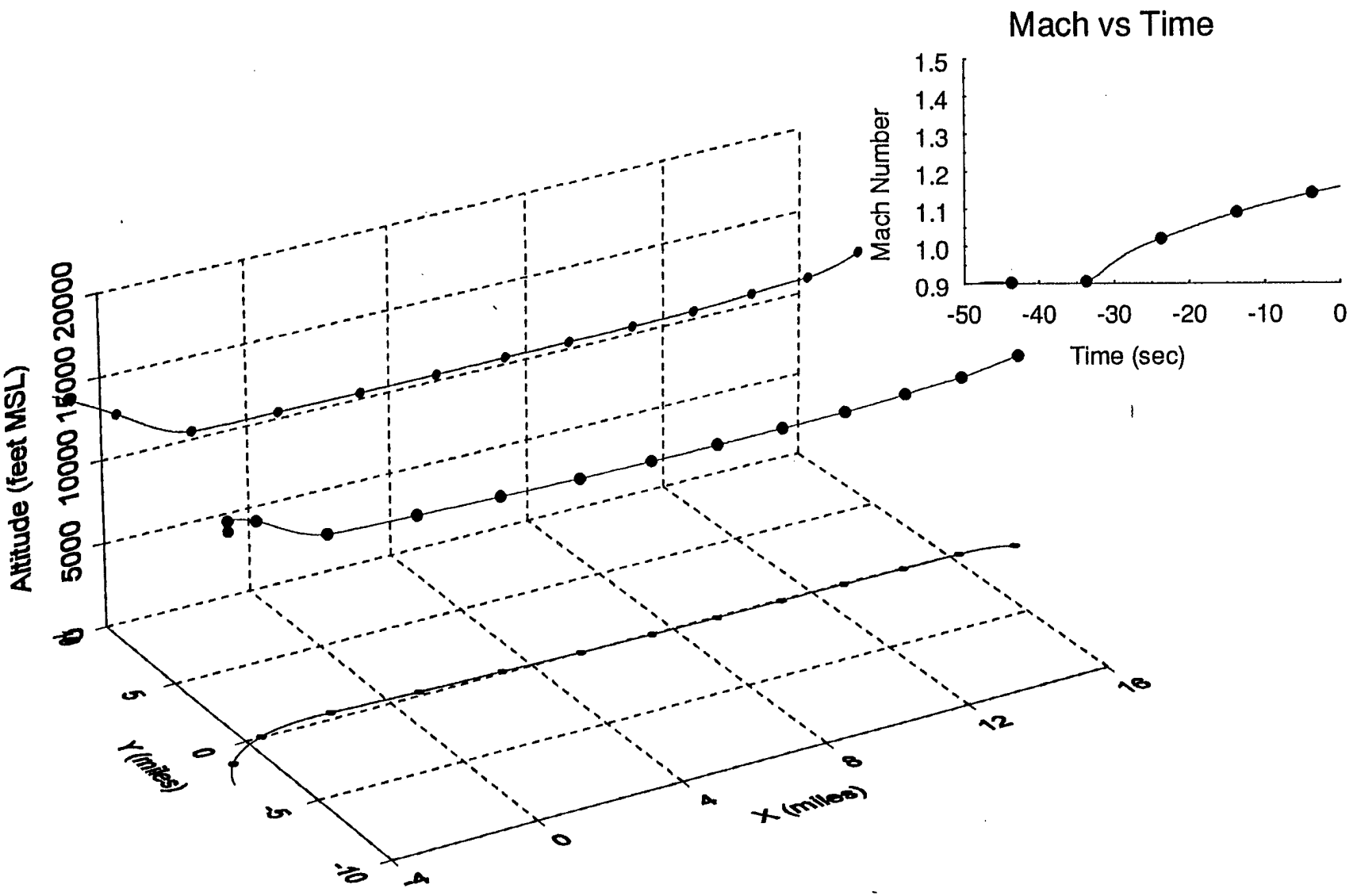

Figure A-25 Flight track for pass 25, level acceleration

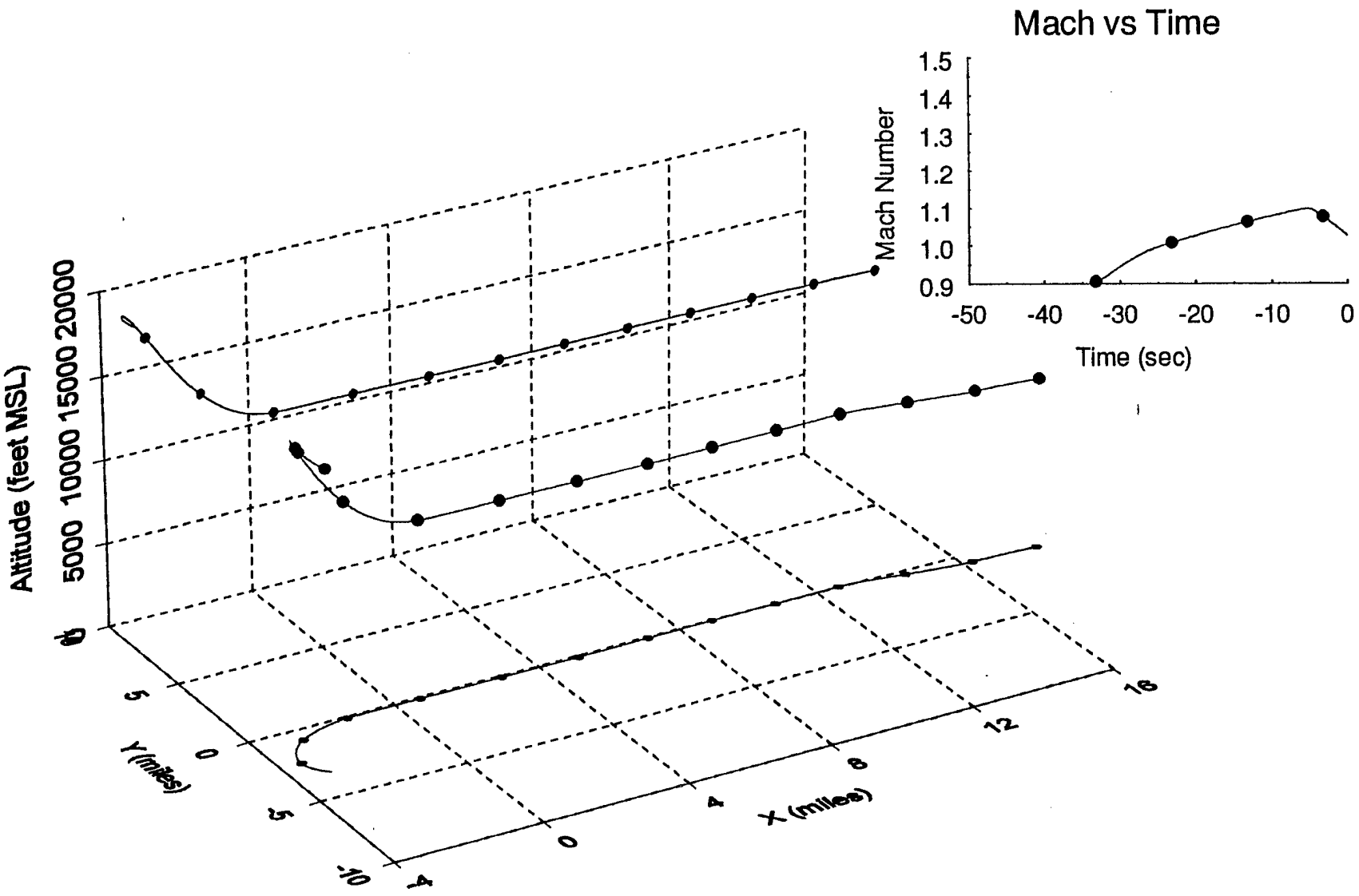

Figure A-26 Flight track for pass 26, level acceleration

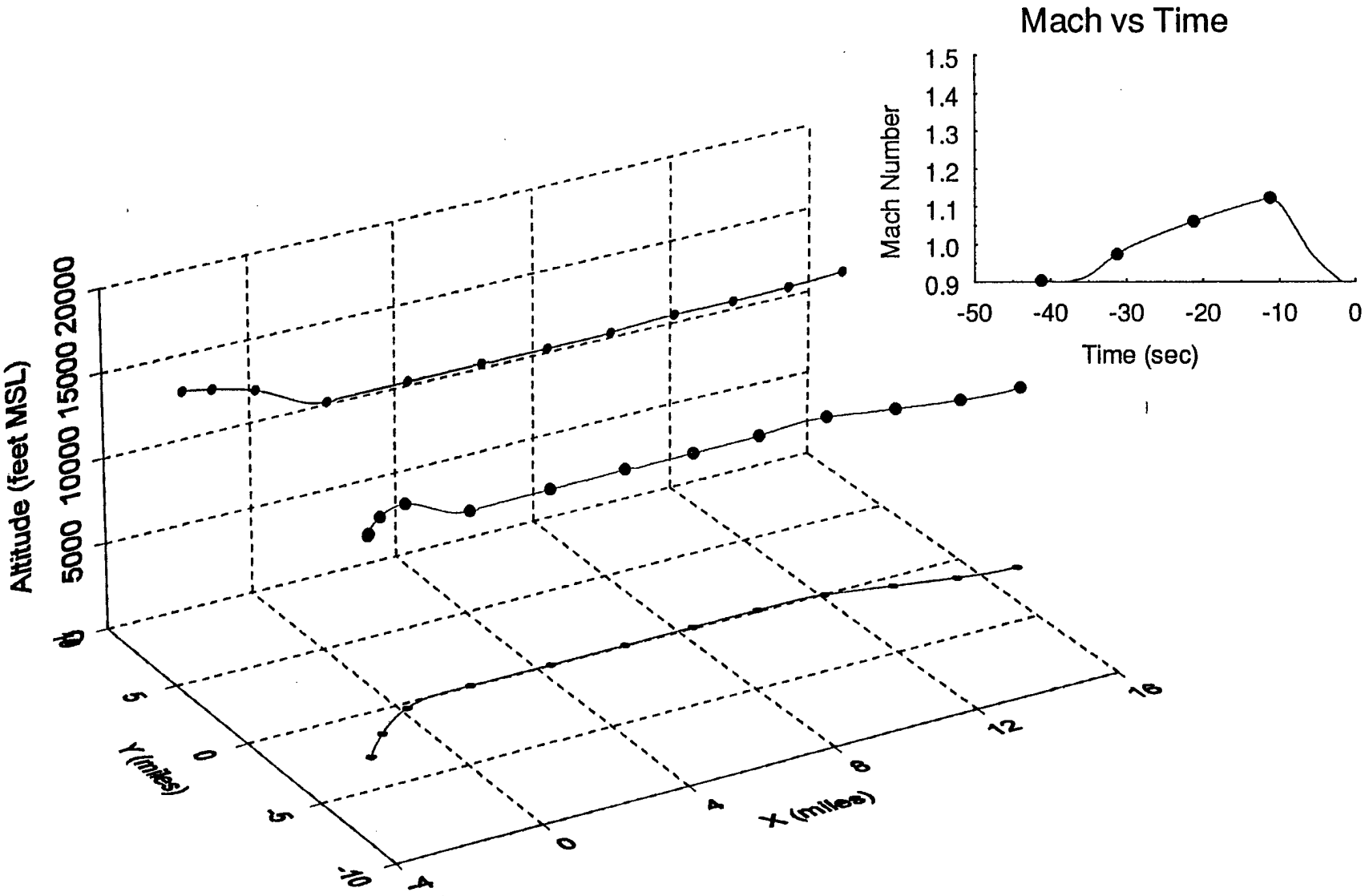

Figure A-27 Flight track for pass 27, level acceleration

hb28trk

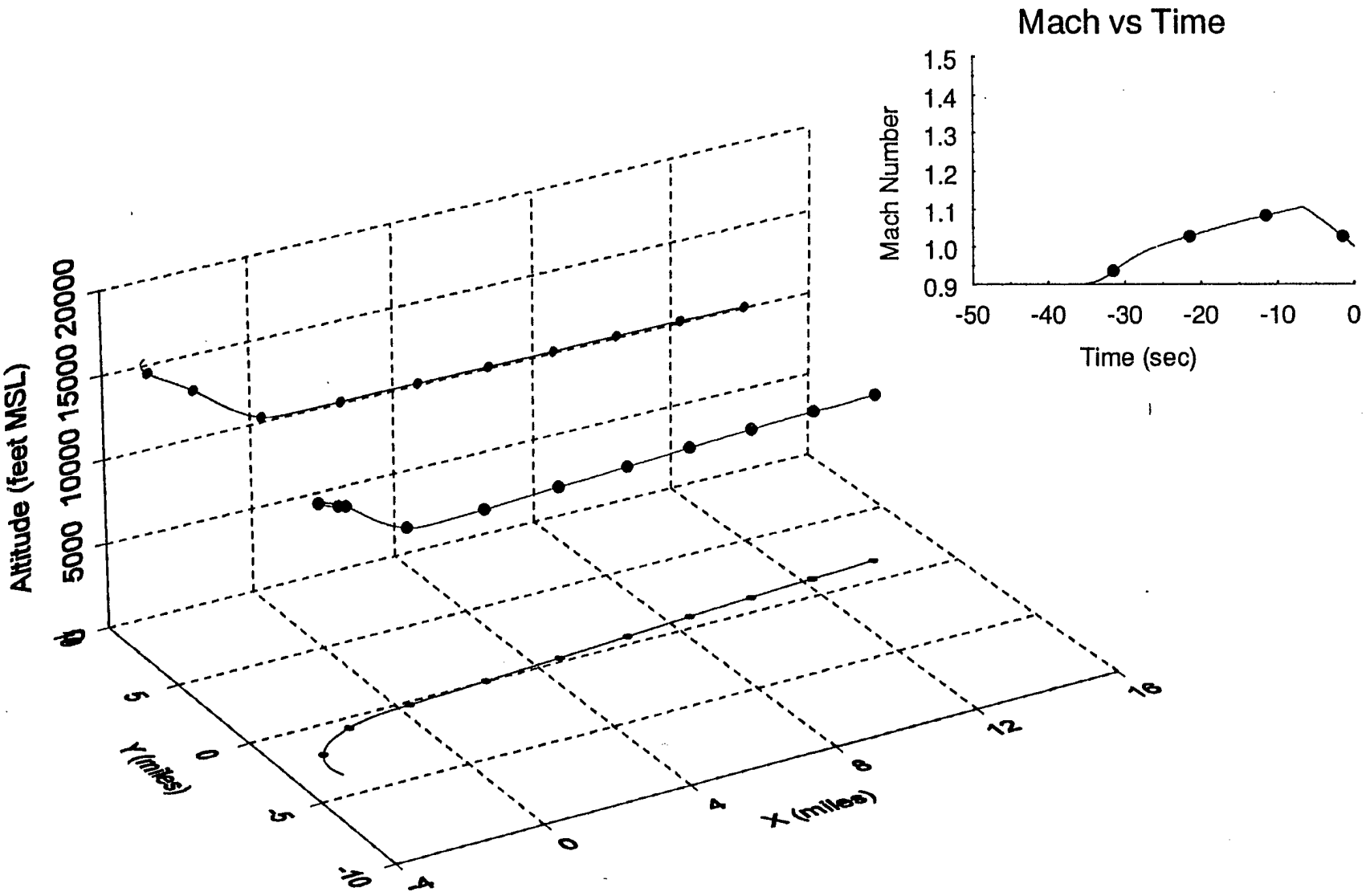

Figure A-28 Flight track for pass 28, level acceleration

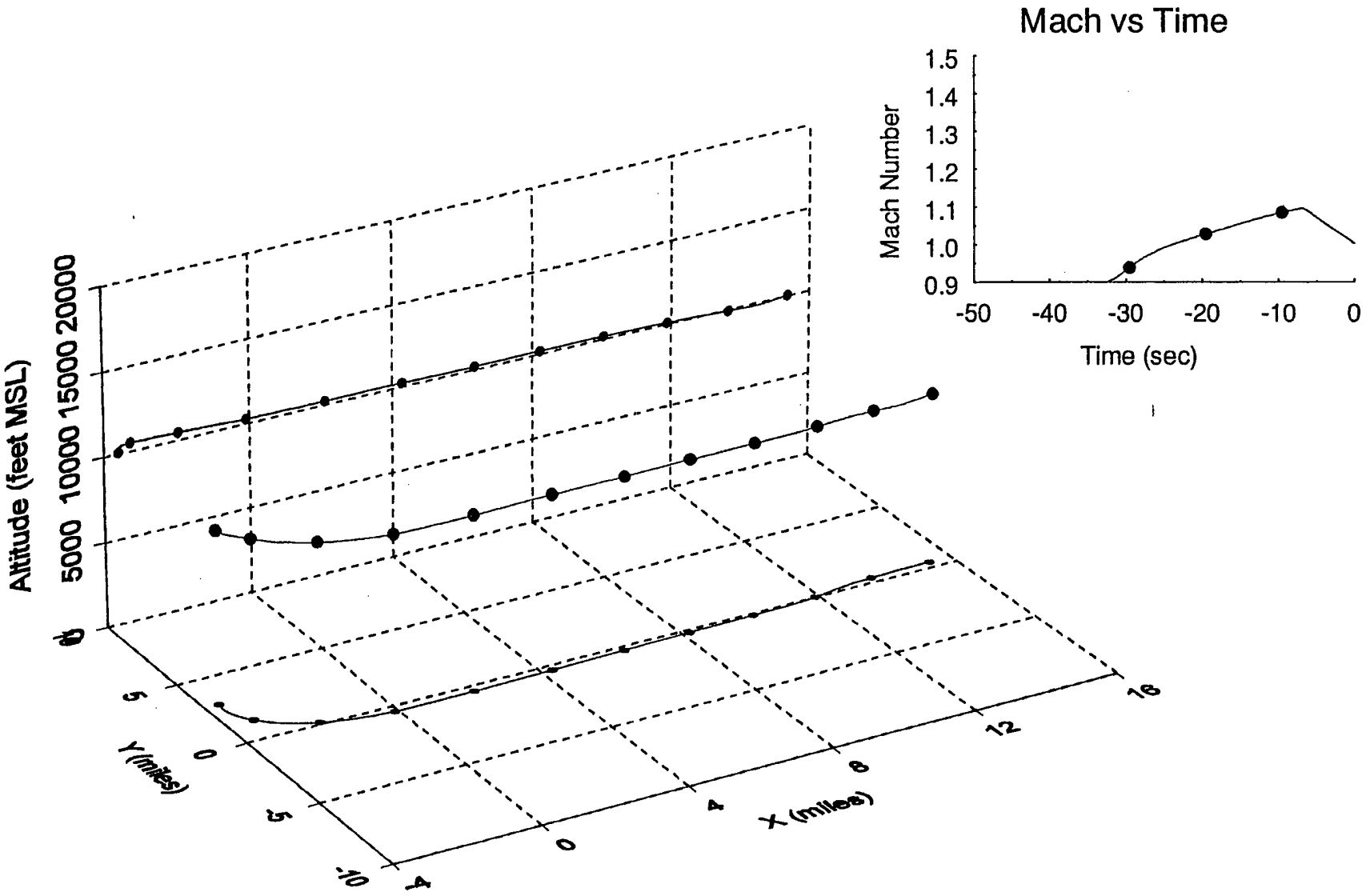

Figure A-29 Flight track for pass 29, level acceleration

PASS 30: NO FLIGHT TRACK DATA AVAILABLE

Figure A-30 Flight track for pass 30, level 4g turn

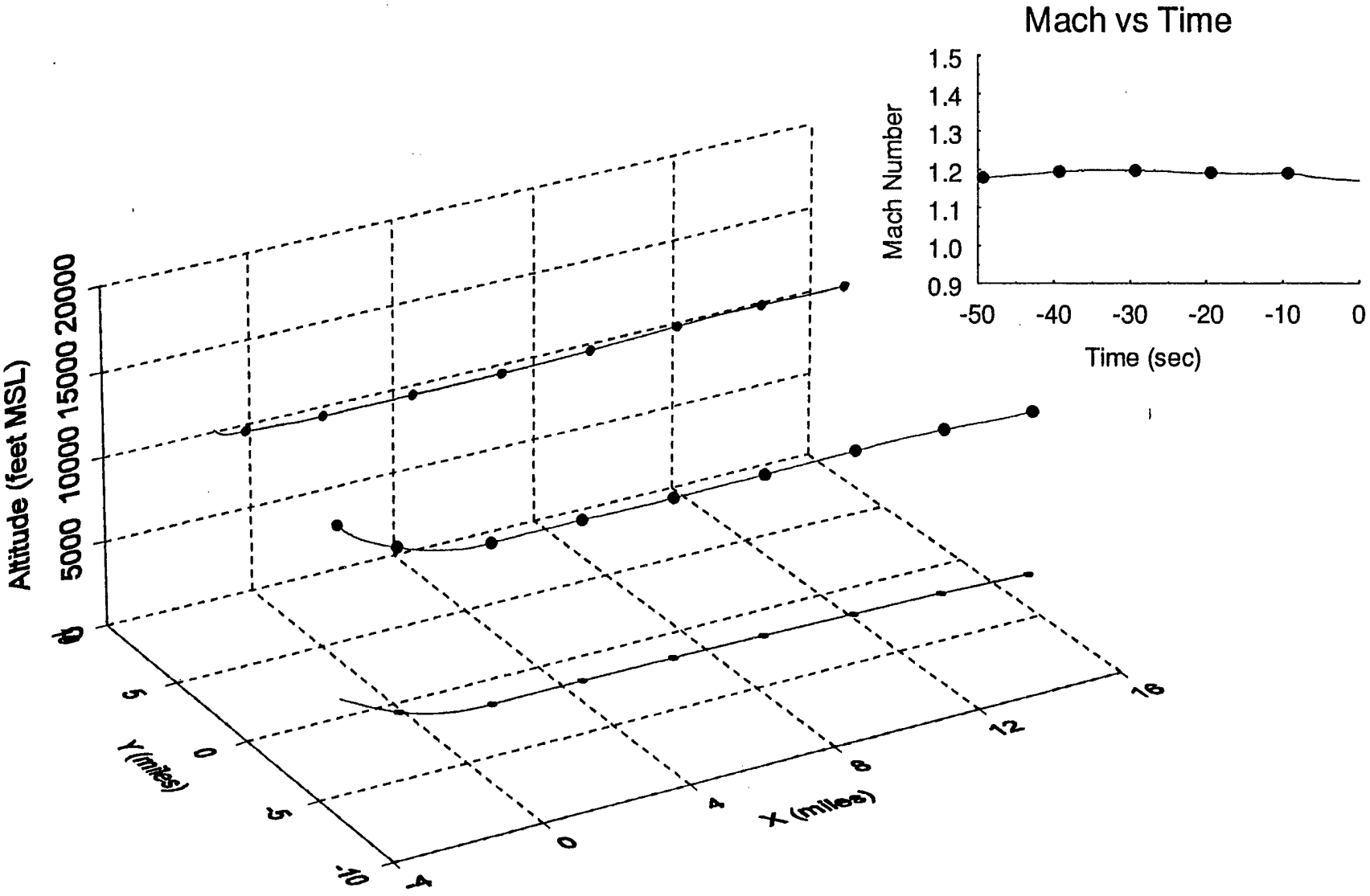

Figure A-31 Flight track for pass 31, level 4g turn

hb32trk

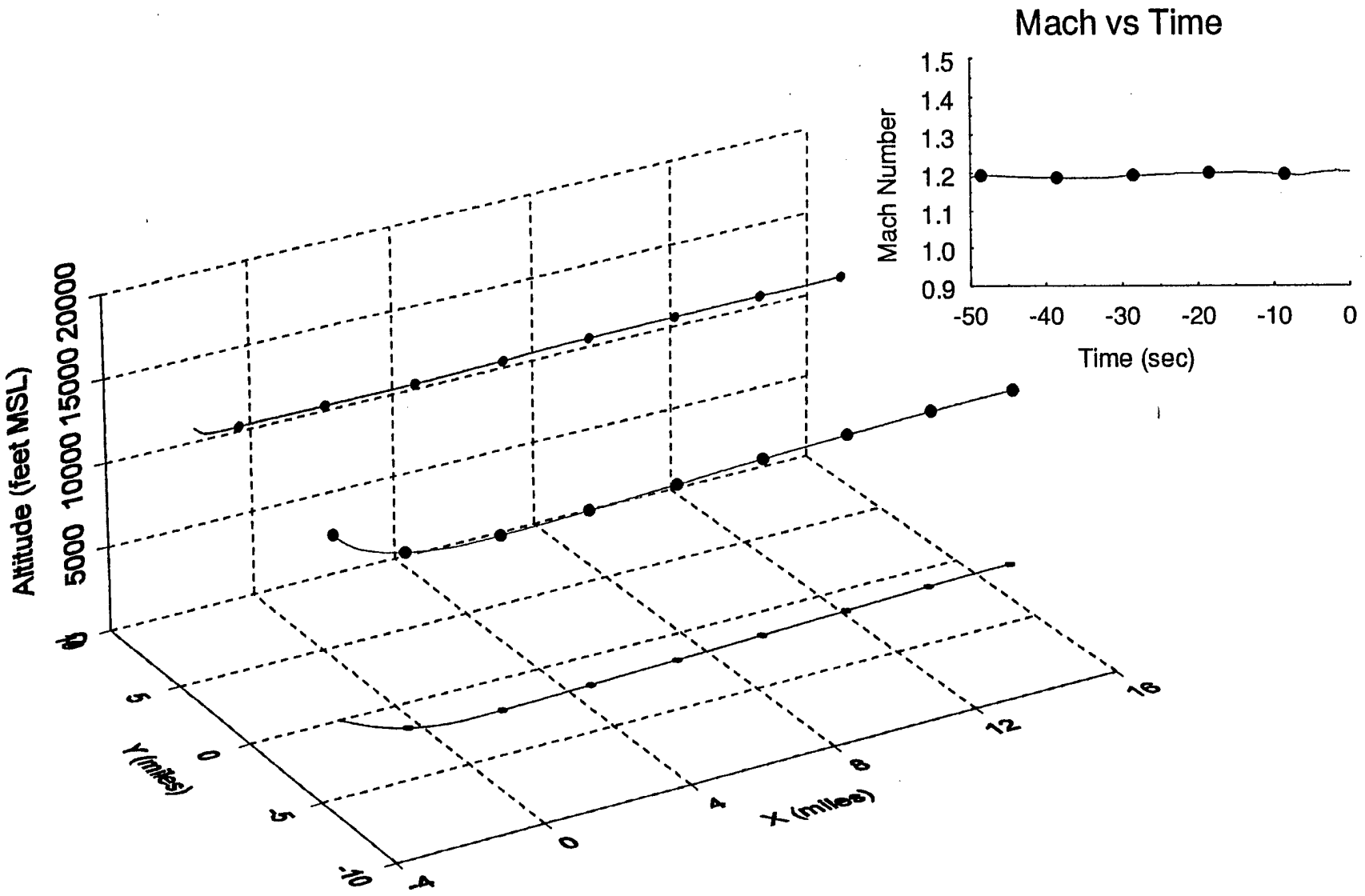

Figure A-32 Flight track for pass 32, level 4g turn

hb33trk

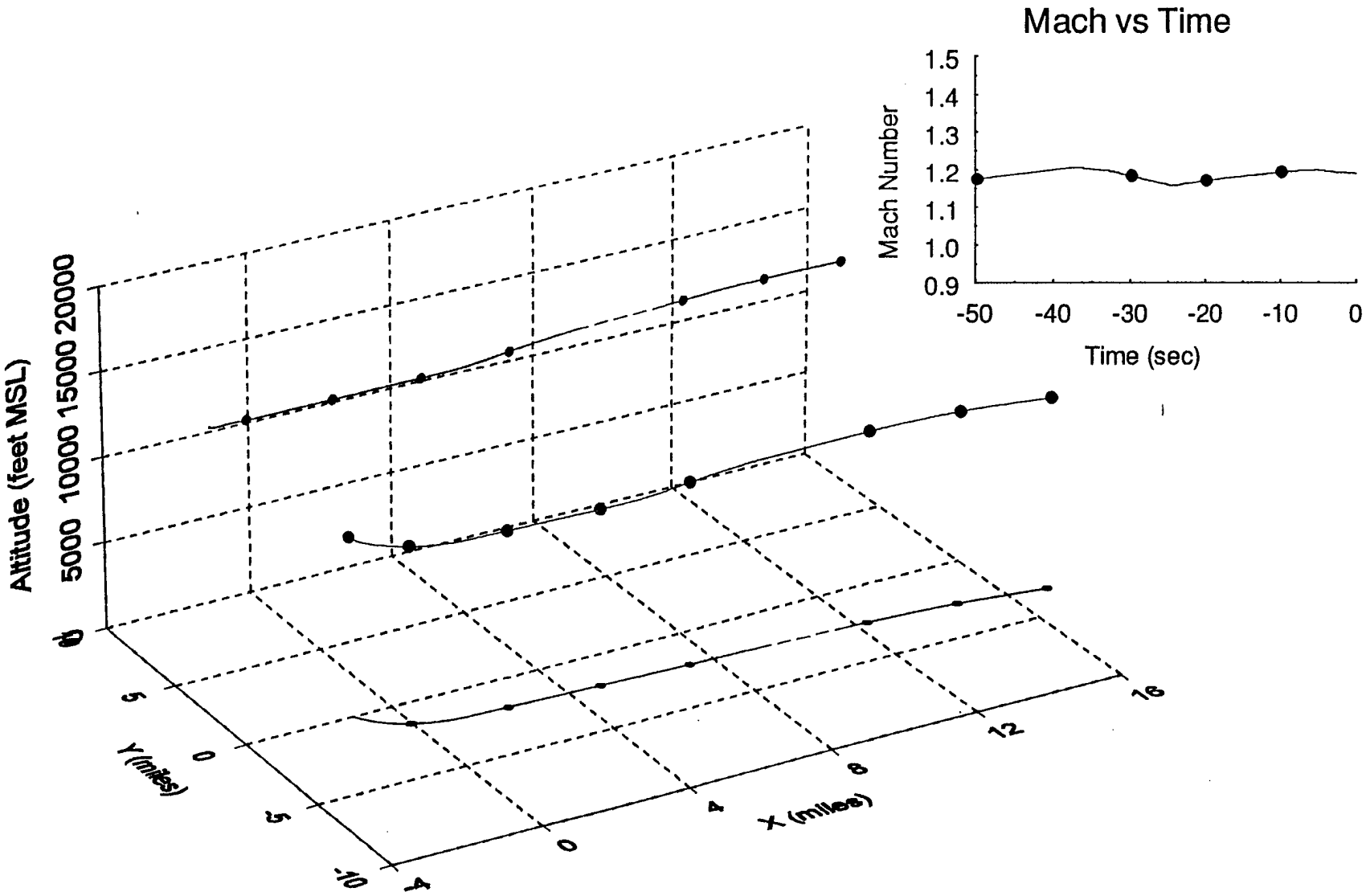

Figure A-33 Flight track for pass 33, level 4g turn

PASS 34: NO FLIGHT TRACK DATA AVAILABLE

Figure A-34 Flight track for pass 34, level 4g turn

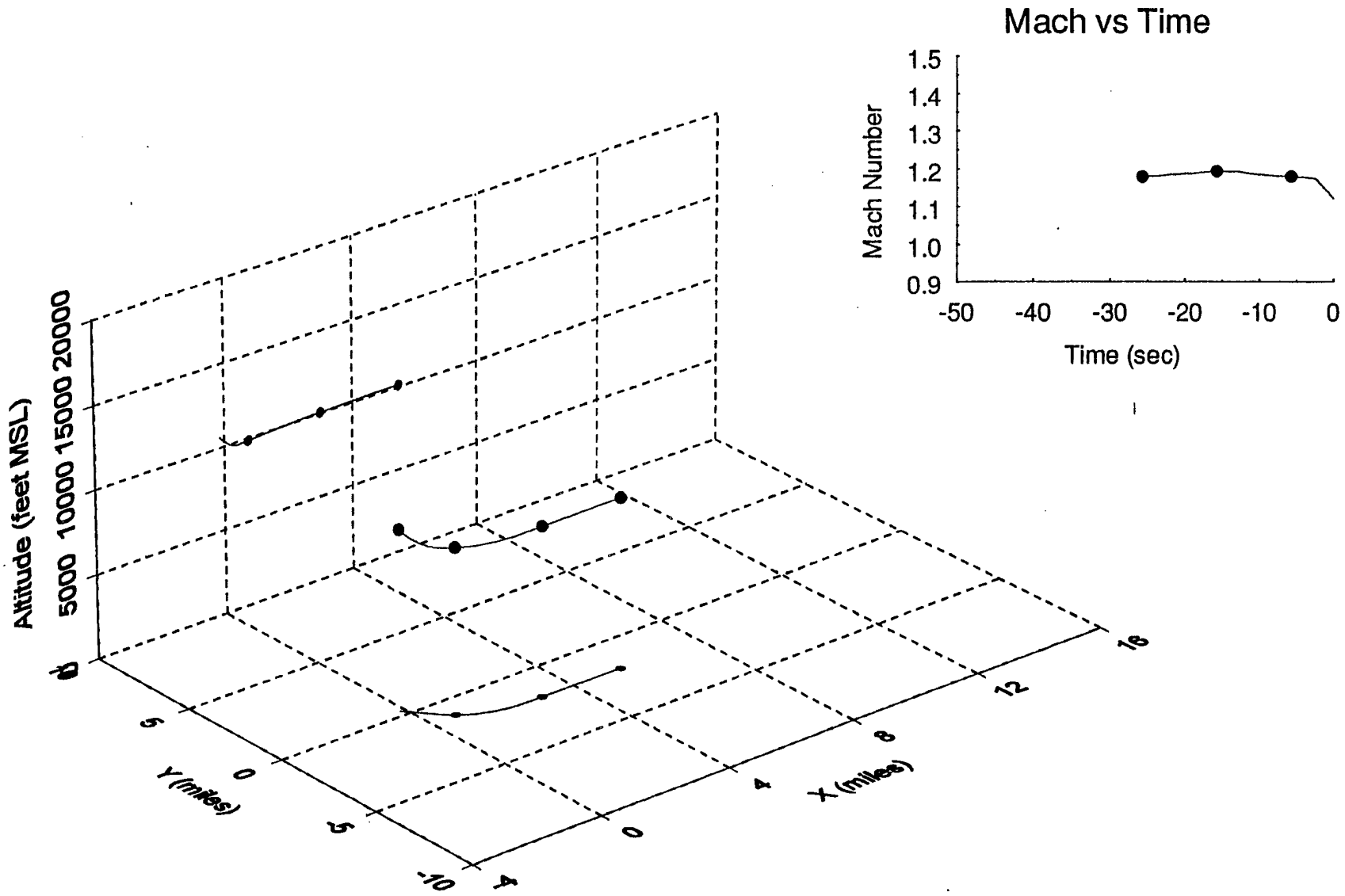

Figure A-35 Flight track for pass 35, level 4g turn

hb36trk

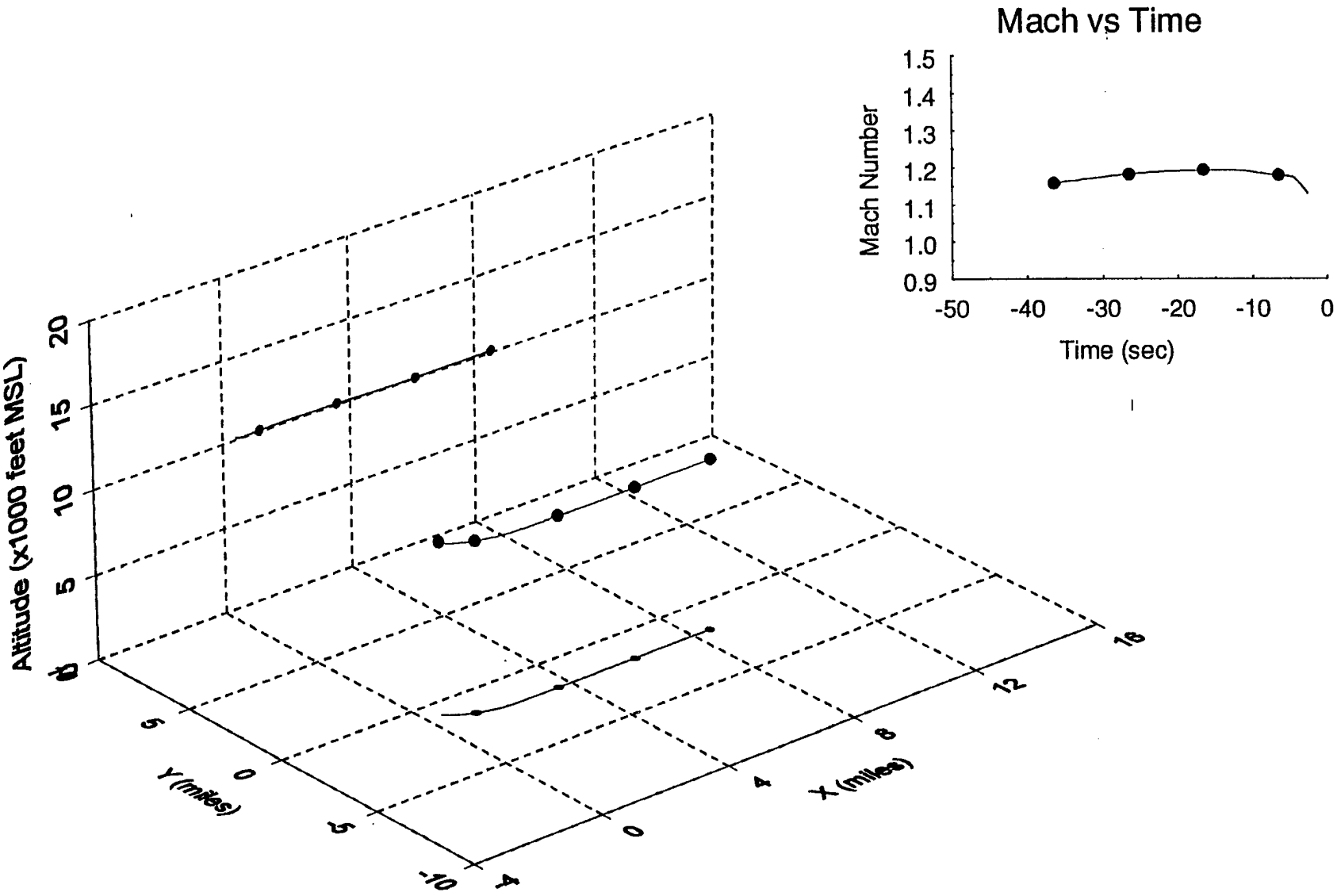

Figure A-36 Flight track for pass 36, level 4g turn

hb37trk

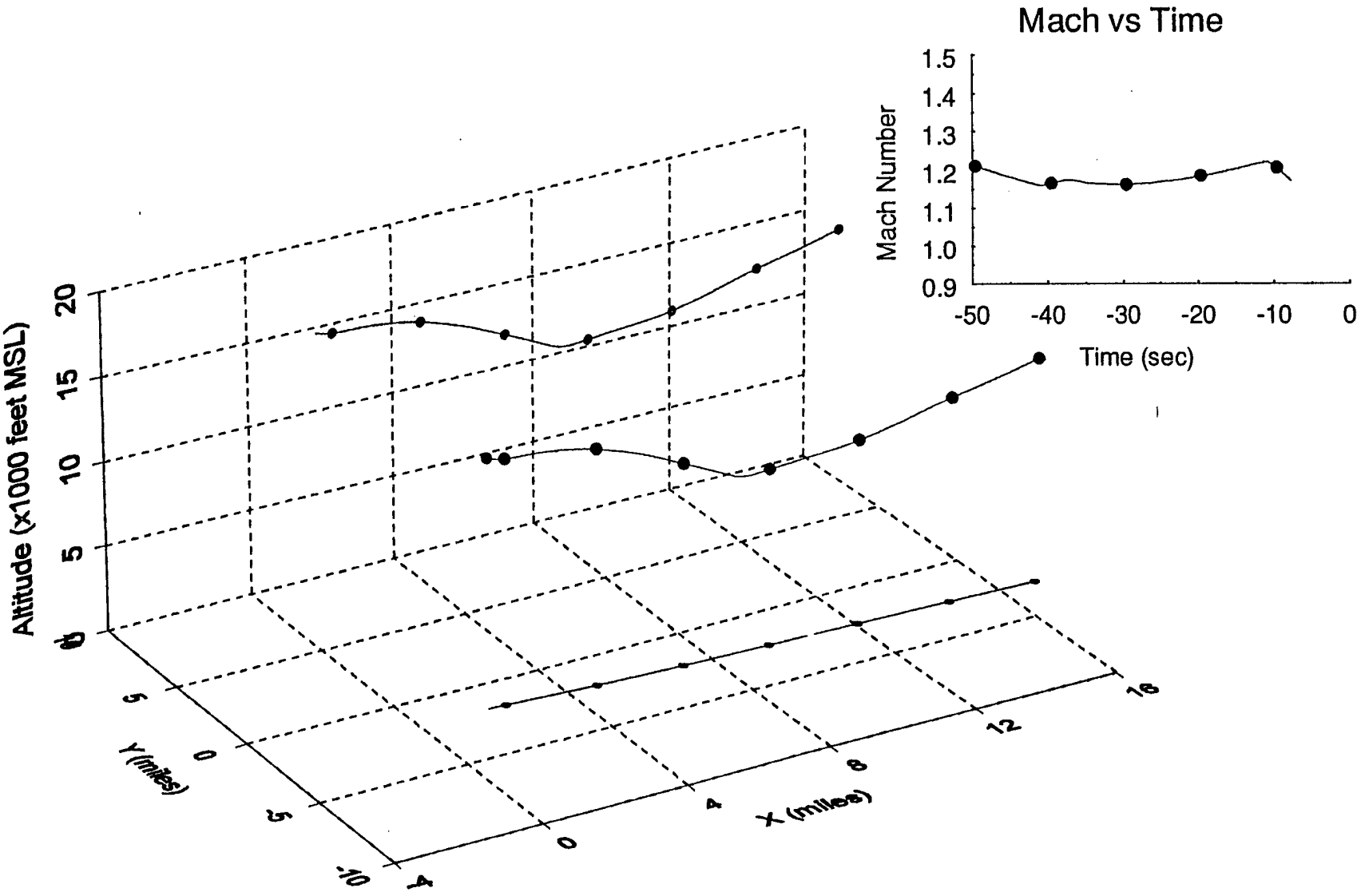

Figure A-37 Flight track for pass 37, climbout/pushover

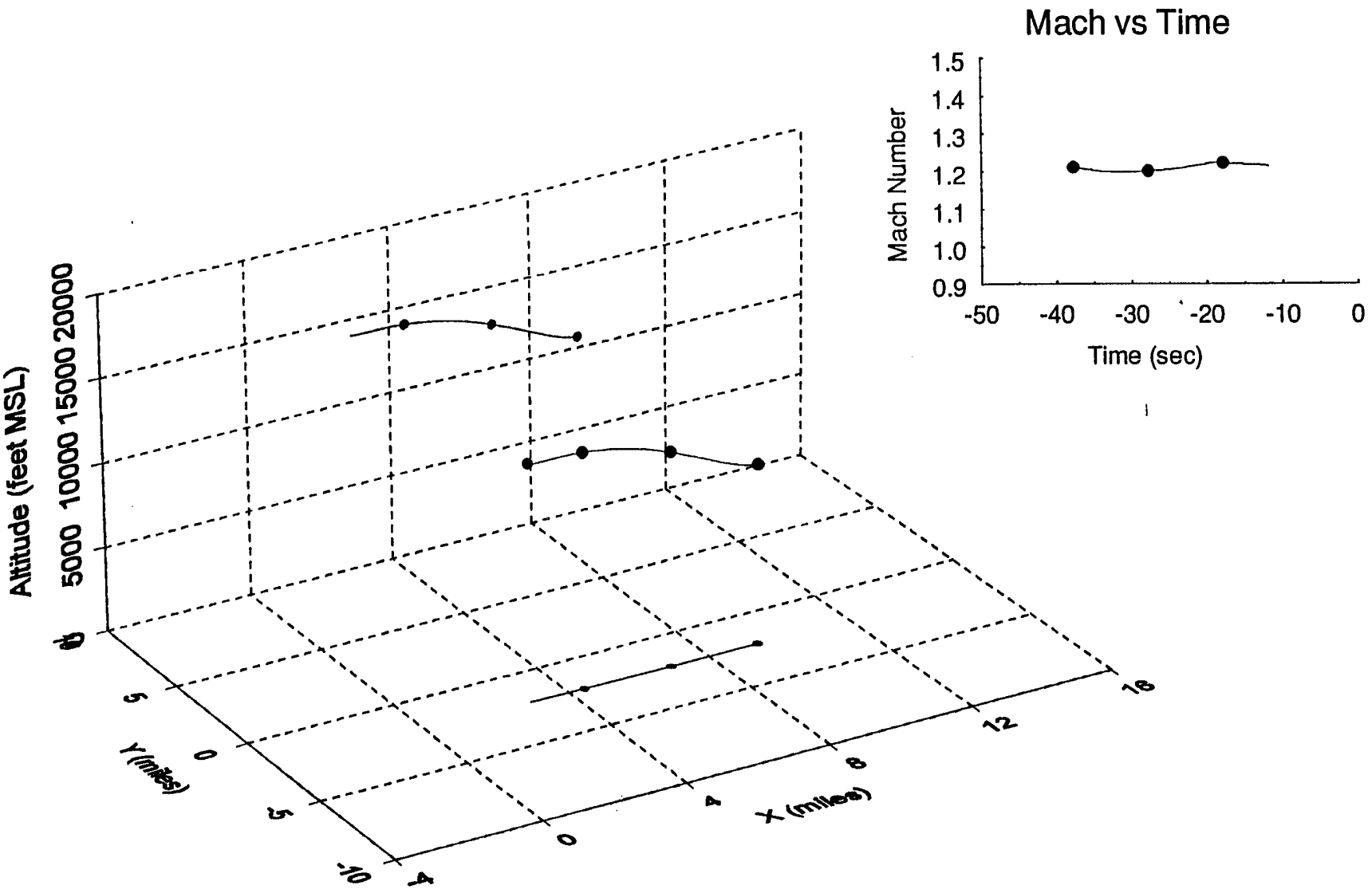

Figure A-38 Flight track for pass 38, climbout/pushover

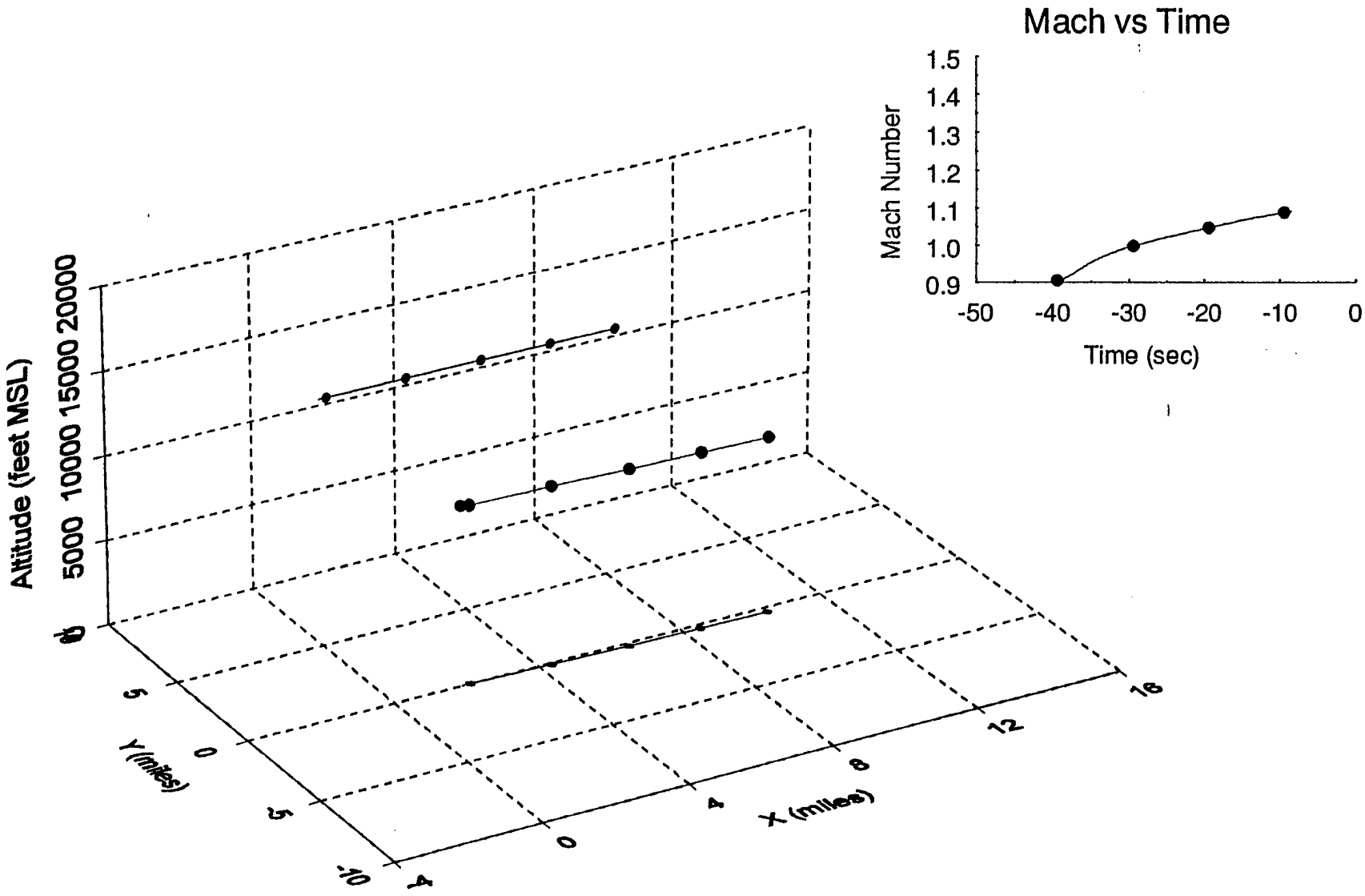

Figure A-39 Flight track for pass 39, level acceleration (autonomous)

hb40trk

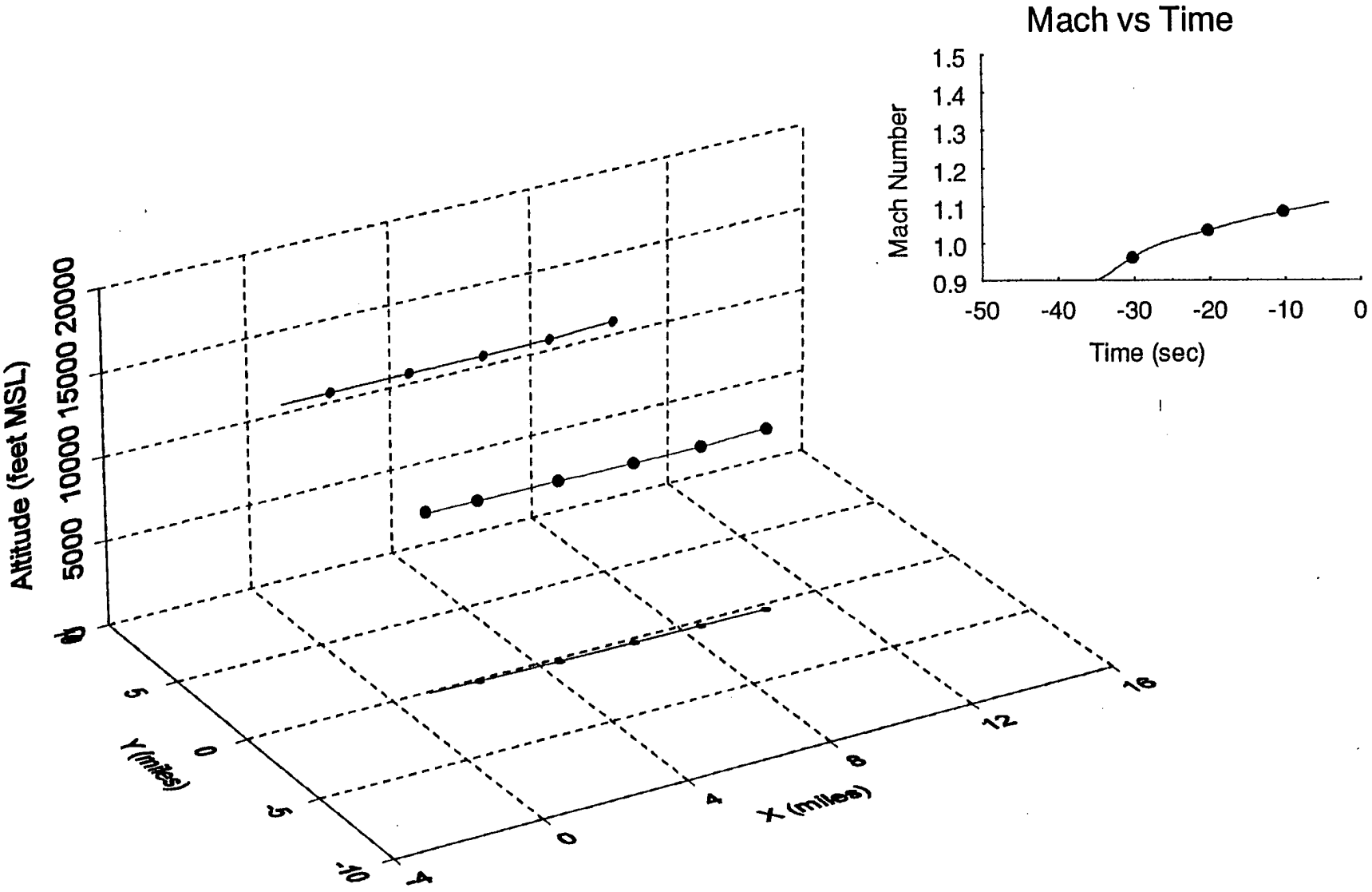

Figure A-40 Flight track for pass 40, level acceleration (autonomous)

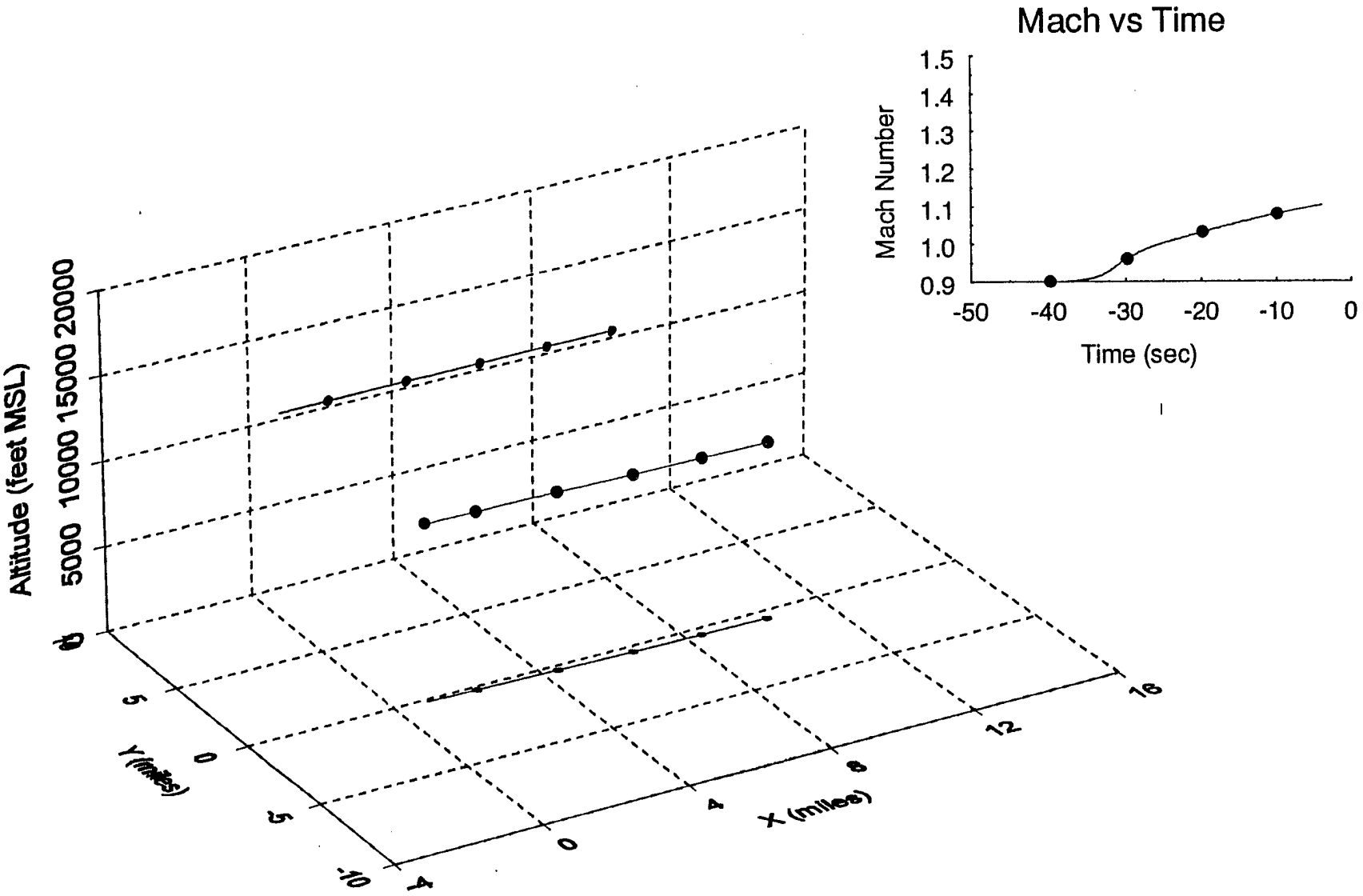

Figure A-41 Flight track for pass 41, level acceleration (autonomous)

hb42trk

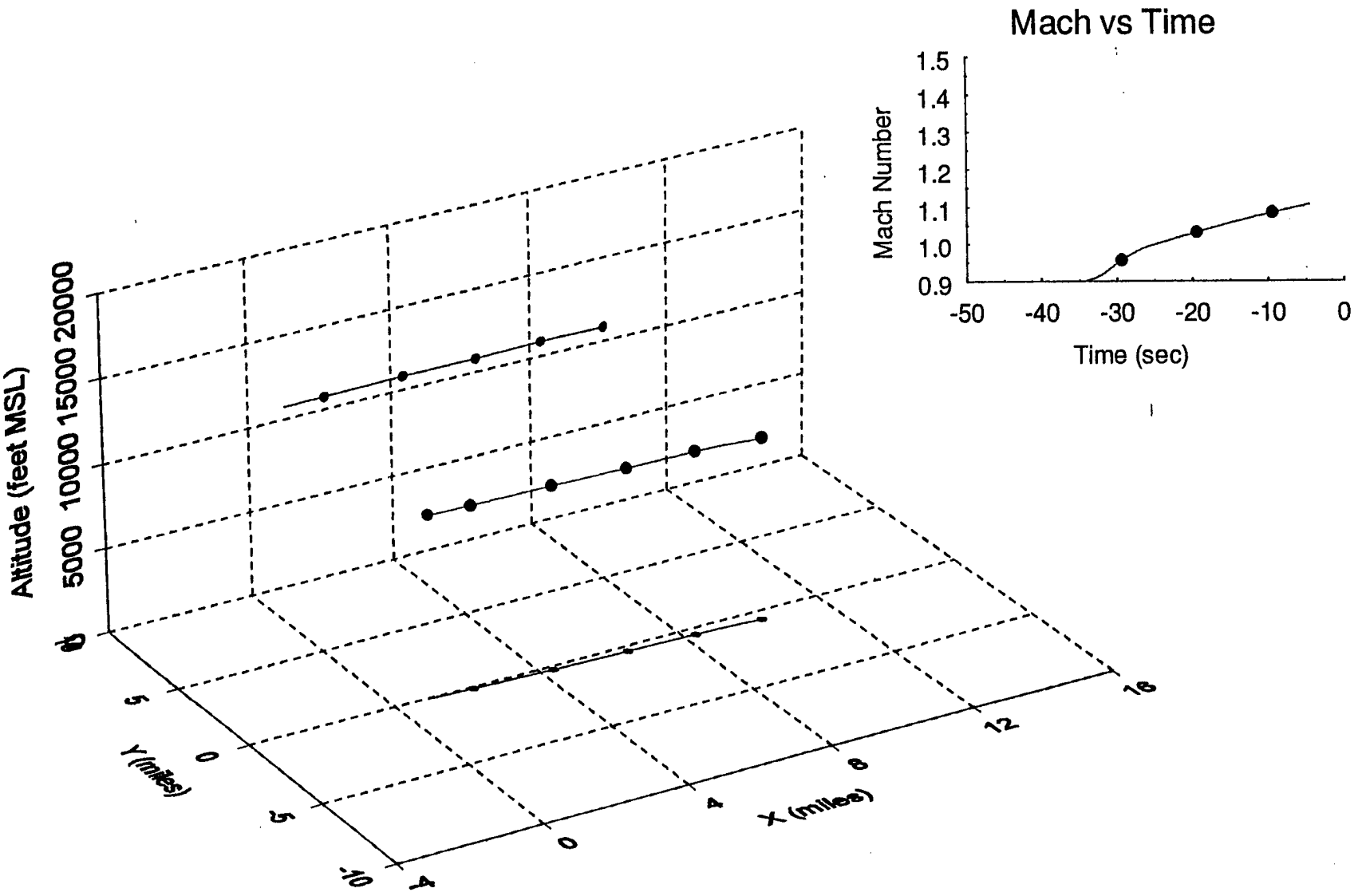

Figure A-42 Flight track for pass 42, level acceleration (autonomous)

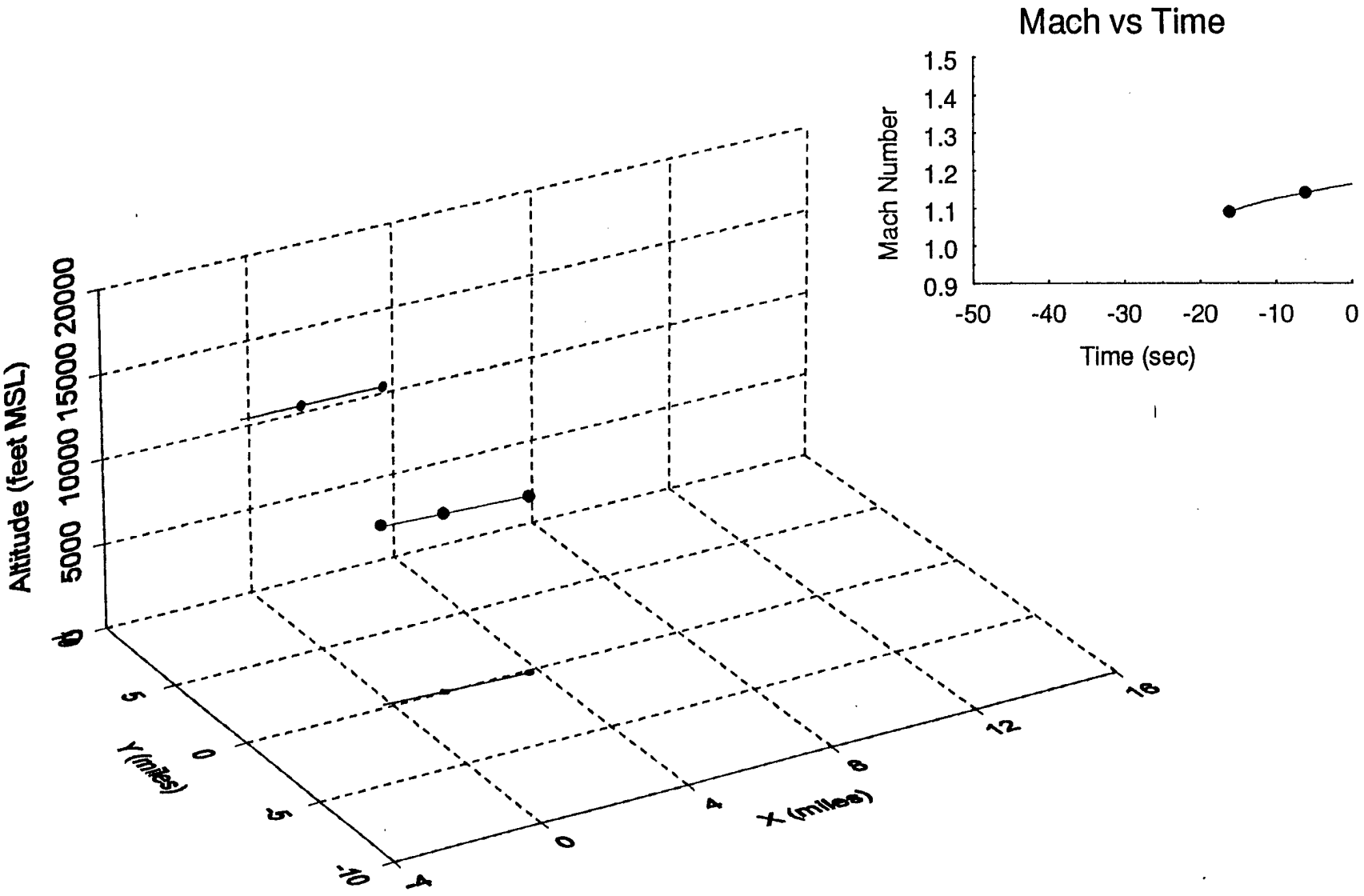

Figure A-43 Flight track for pass 43, level acceleration (autonomous)

hb44trk

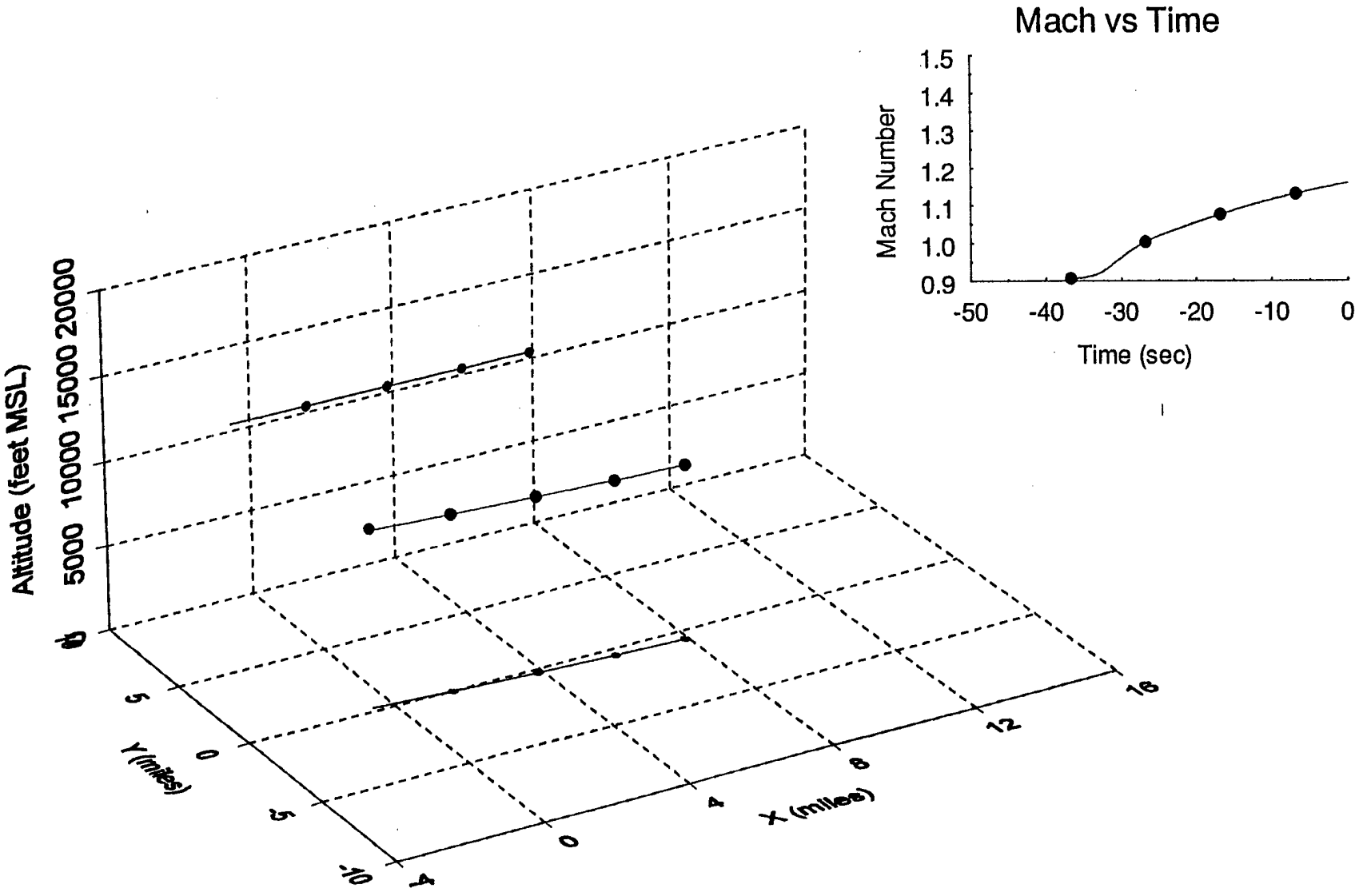

Figure A-44 Flight track for pass 44, level acceleration (autonomous)

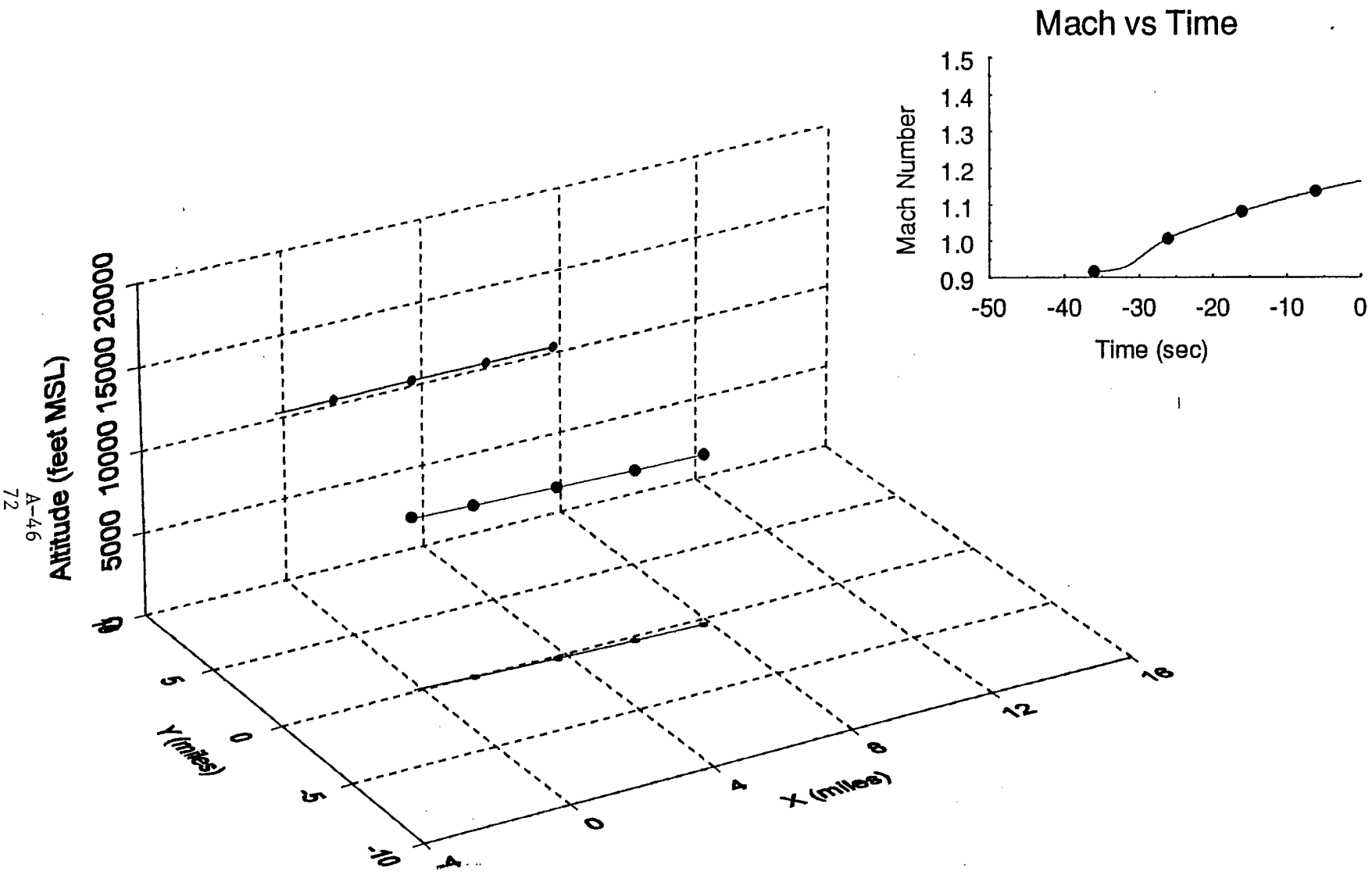

Figure A-45 Flight track for pass 45, level acceleration (autonomous)

hb46trk

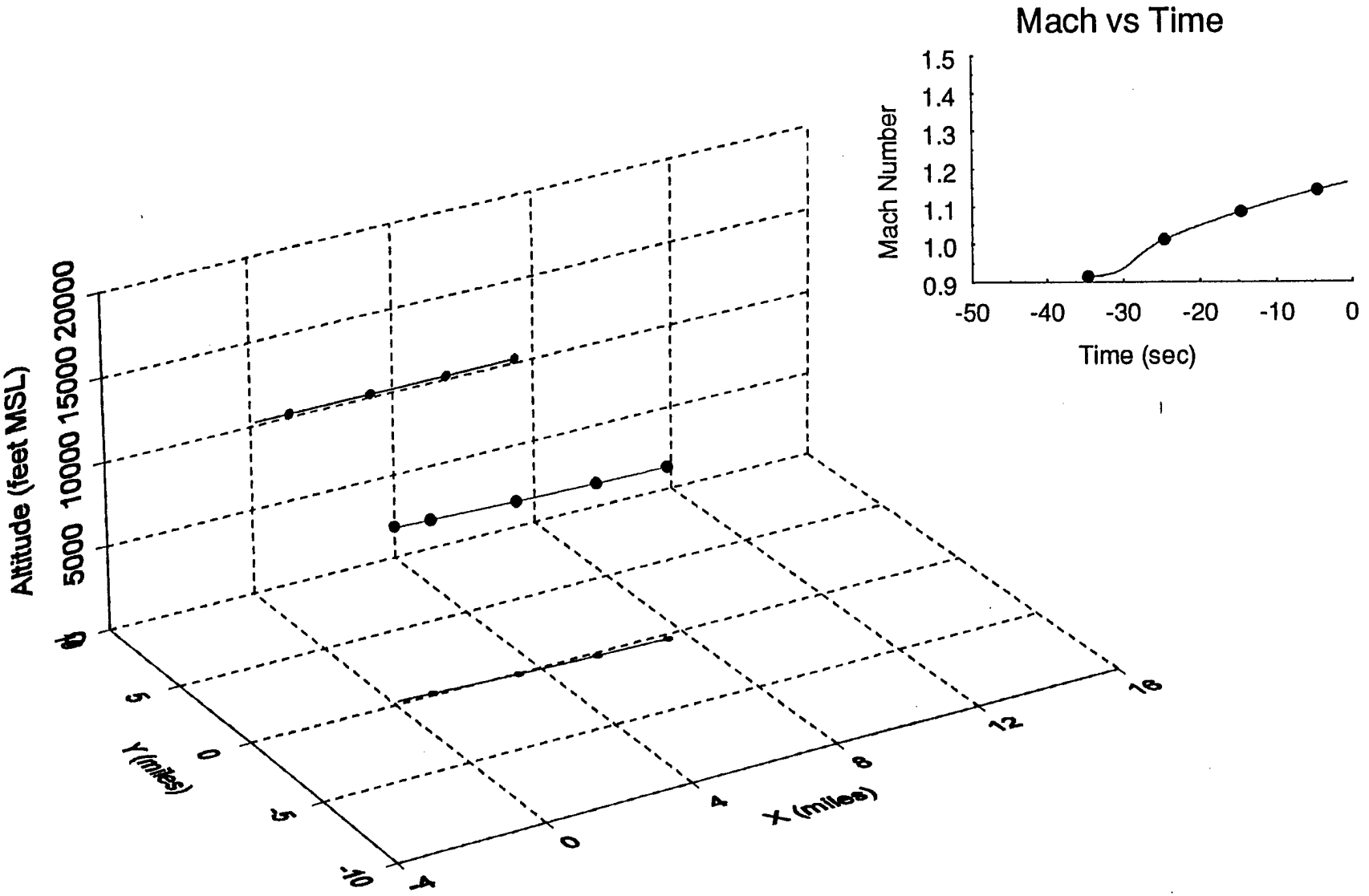

Figure A-46 Flight track for pass 46, level acceleration (autonomous)

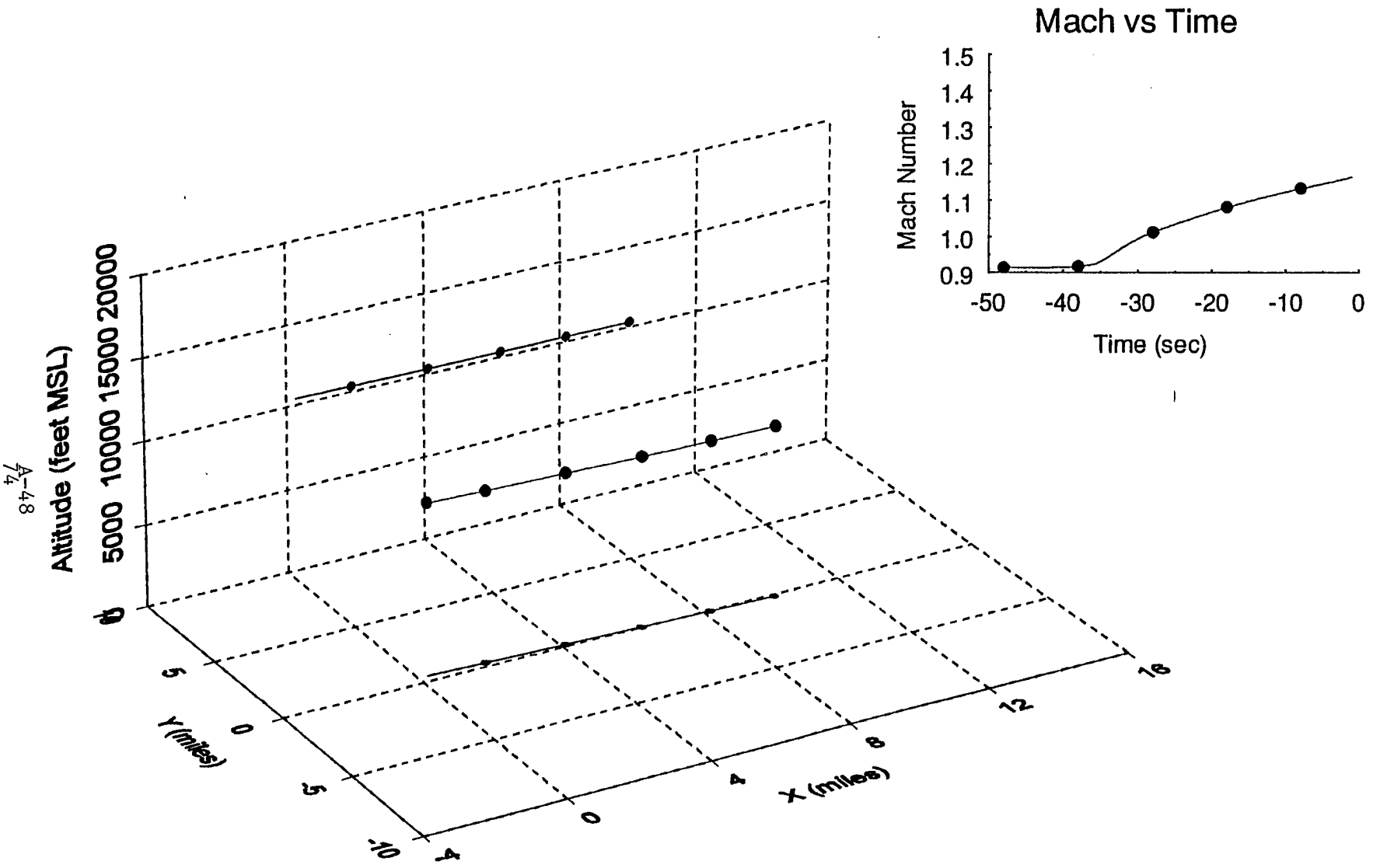

Figure A-47 Flight track for pass 47, level acceleration (autonomous)

hb48trk

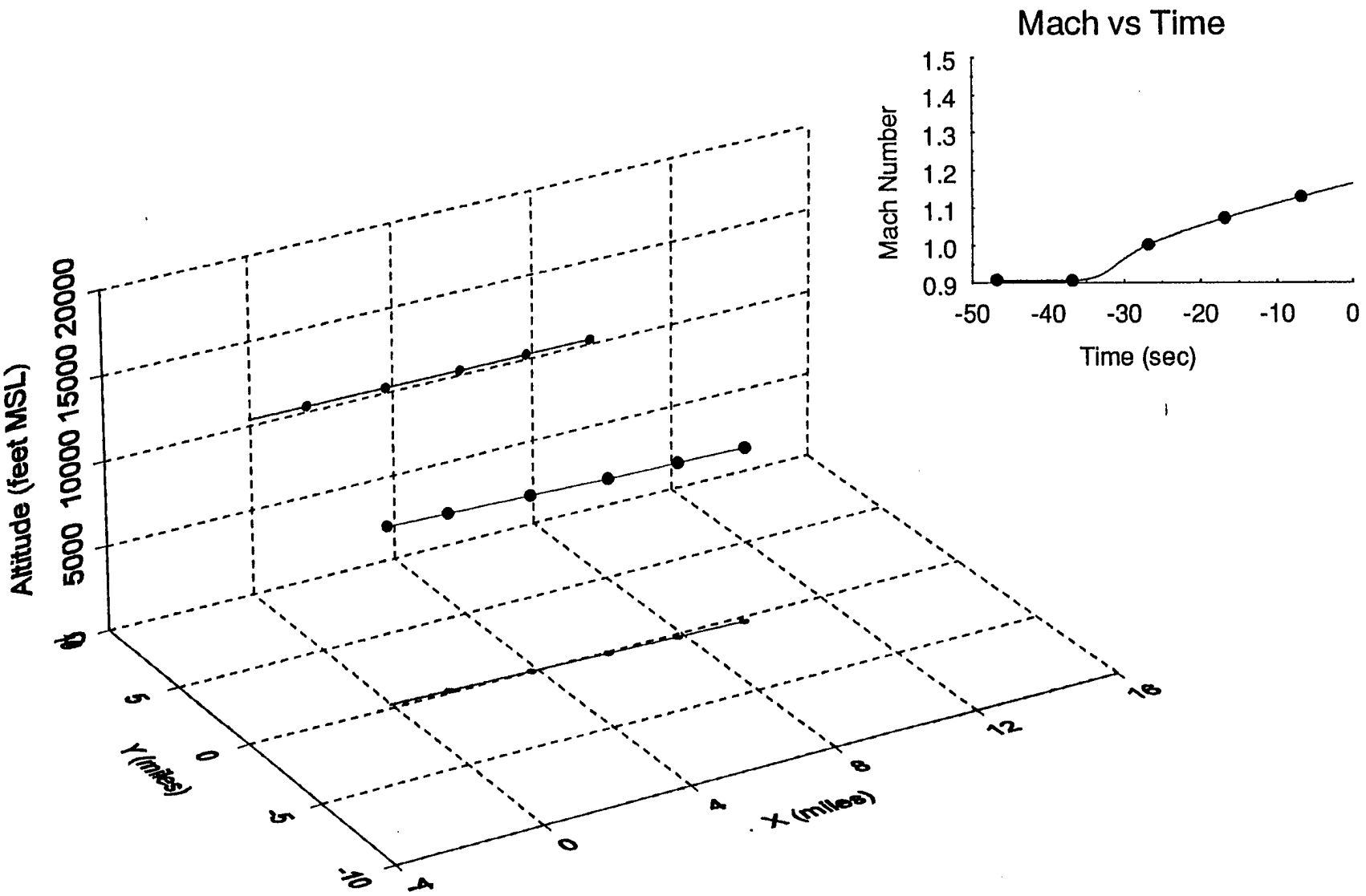

Figure A-48 Flight track for pass 48, level acceleration (autonomous)

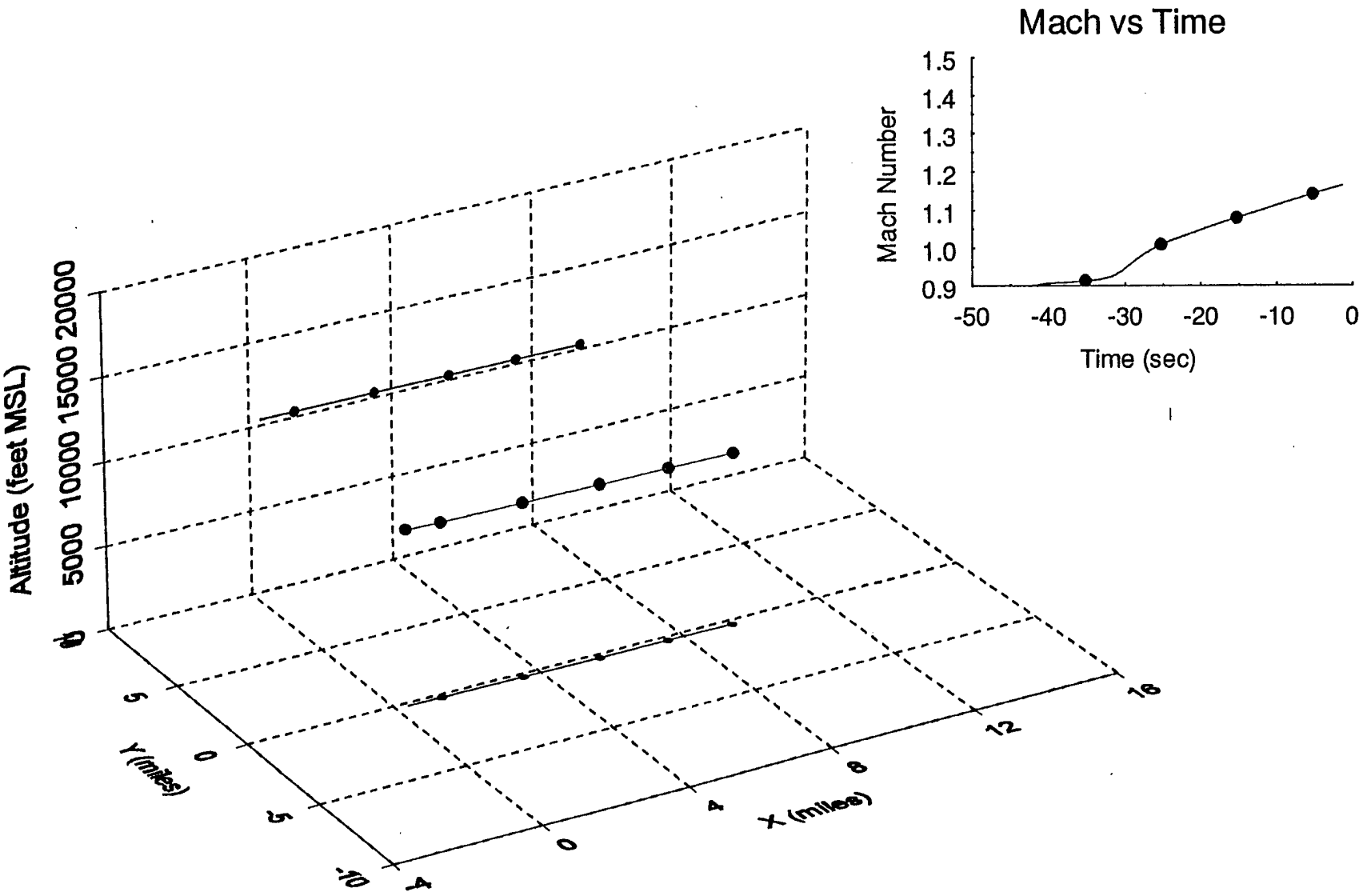

Figure A-49 Flight track for pass 49, level acceleration (autonomous)

APPENDIX B: ATMOSPHERIC DATA

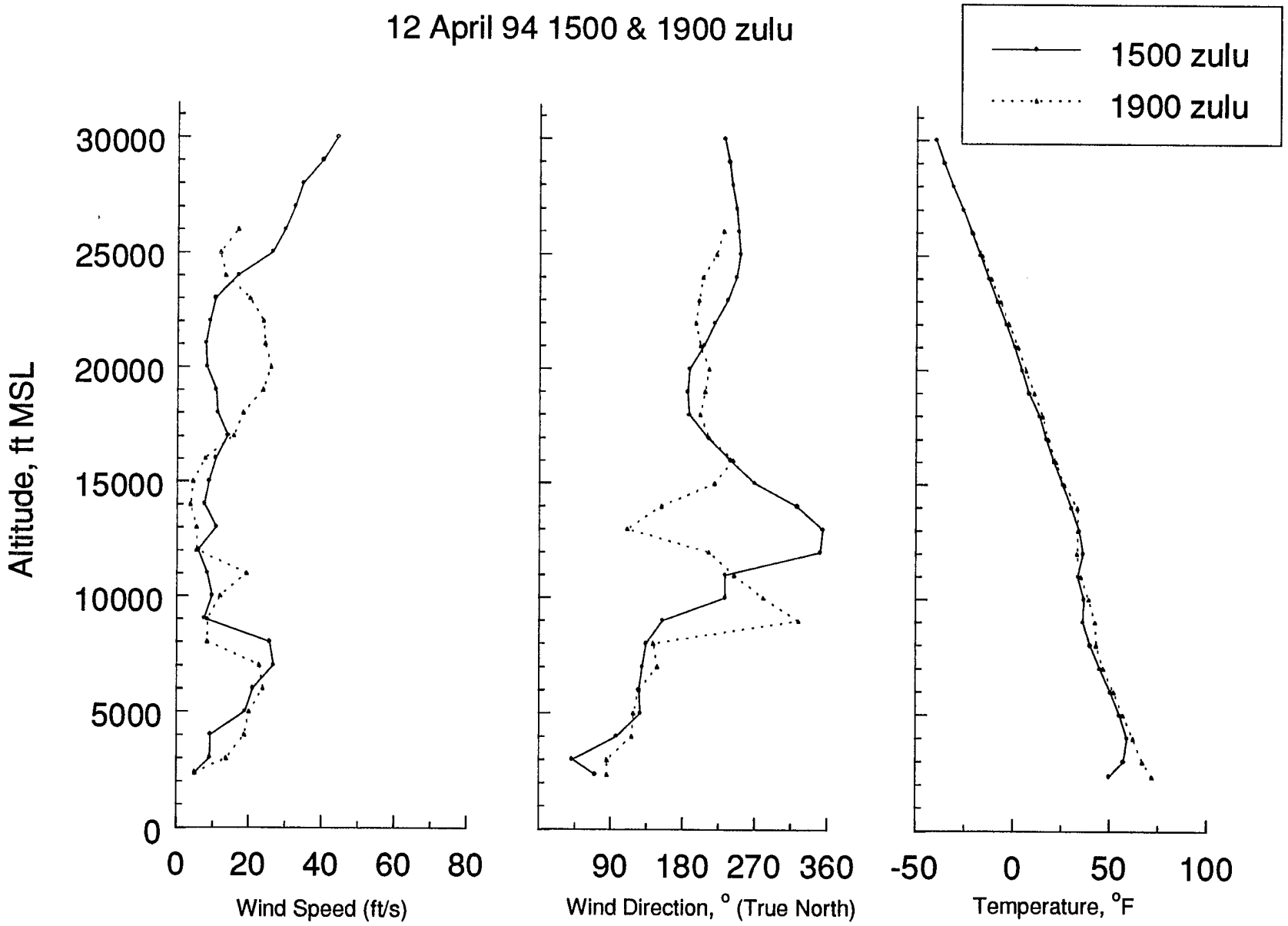

Figure B-1. Atmospheric profiles for 12 April 1994

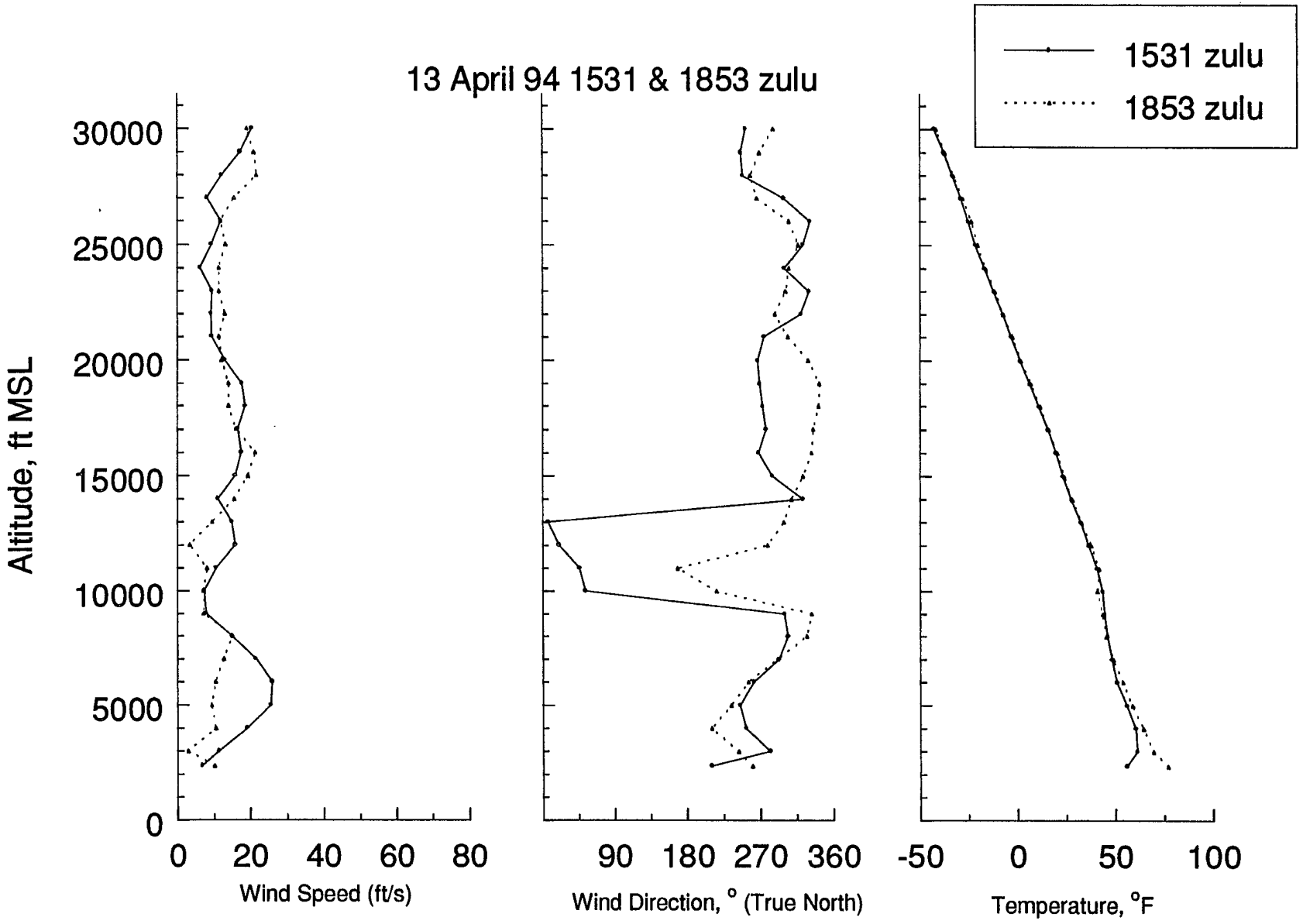

Figure B-2. Atmospheric profiles for 13 April 1994

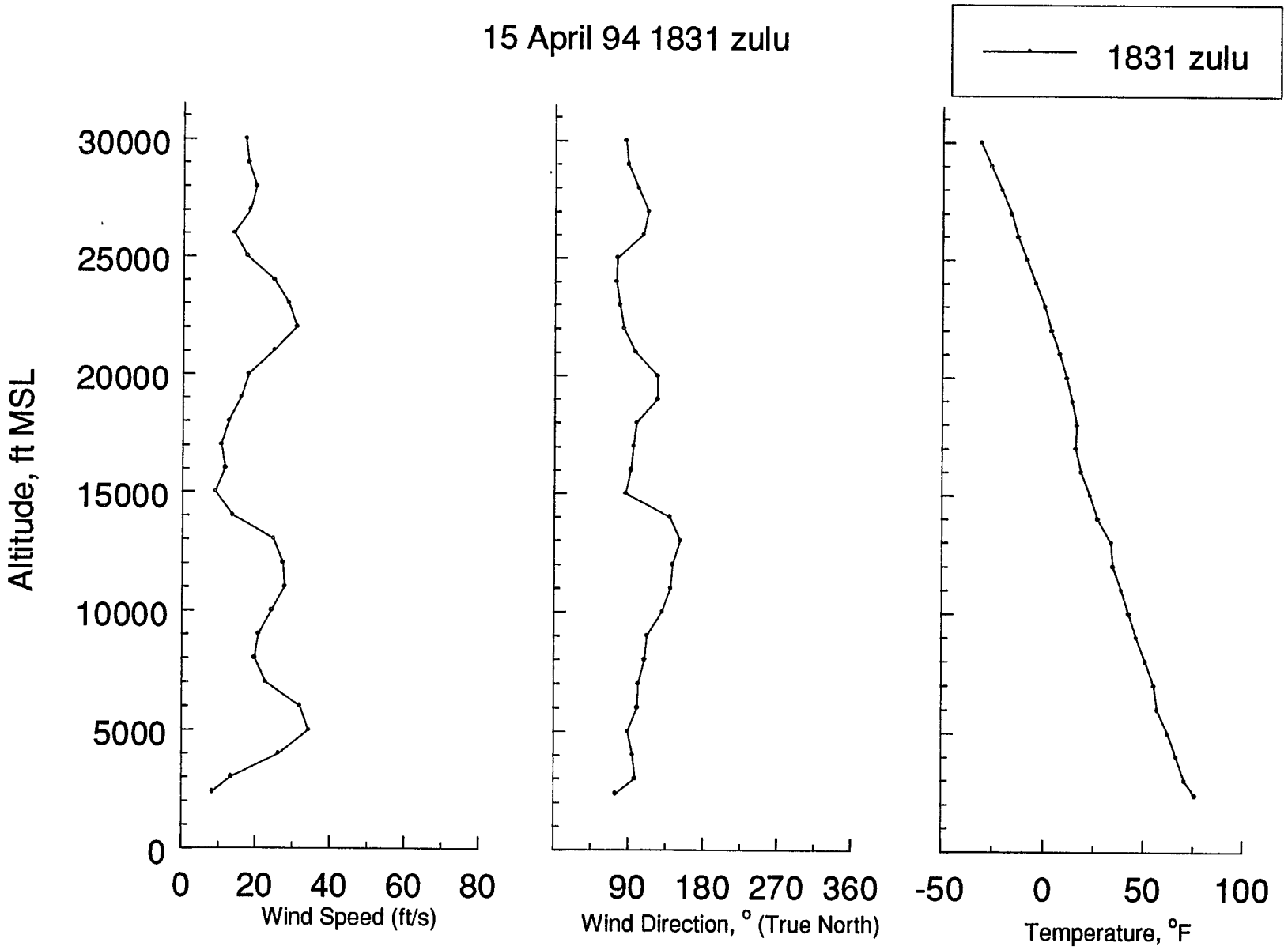

Figure B-3. Atmospheric profile for 15 April 1994

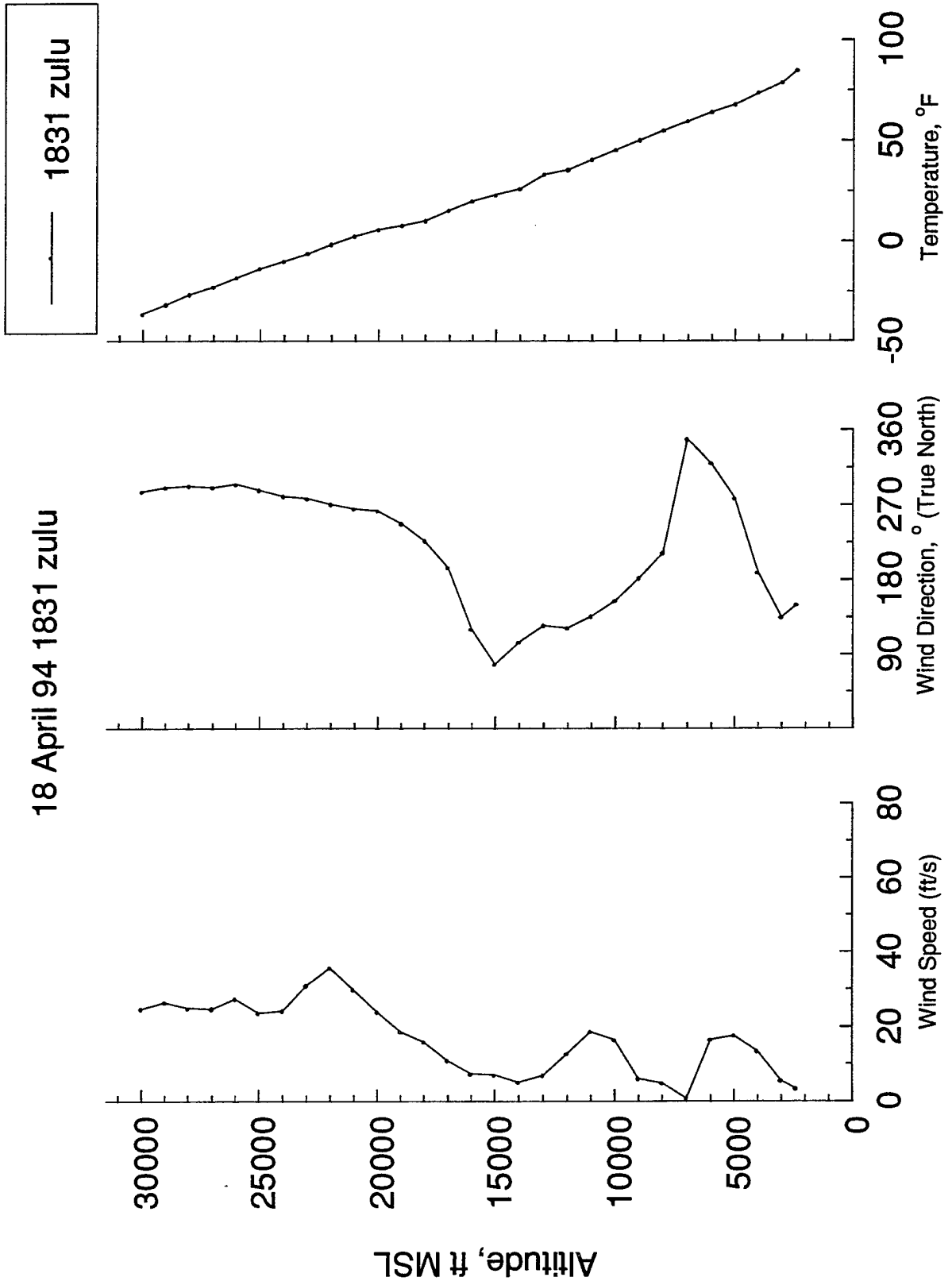

Figure B-4. Atmospheric profile for 18 April 1994

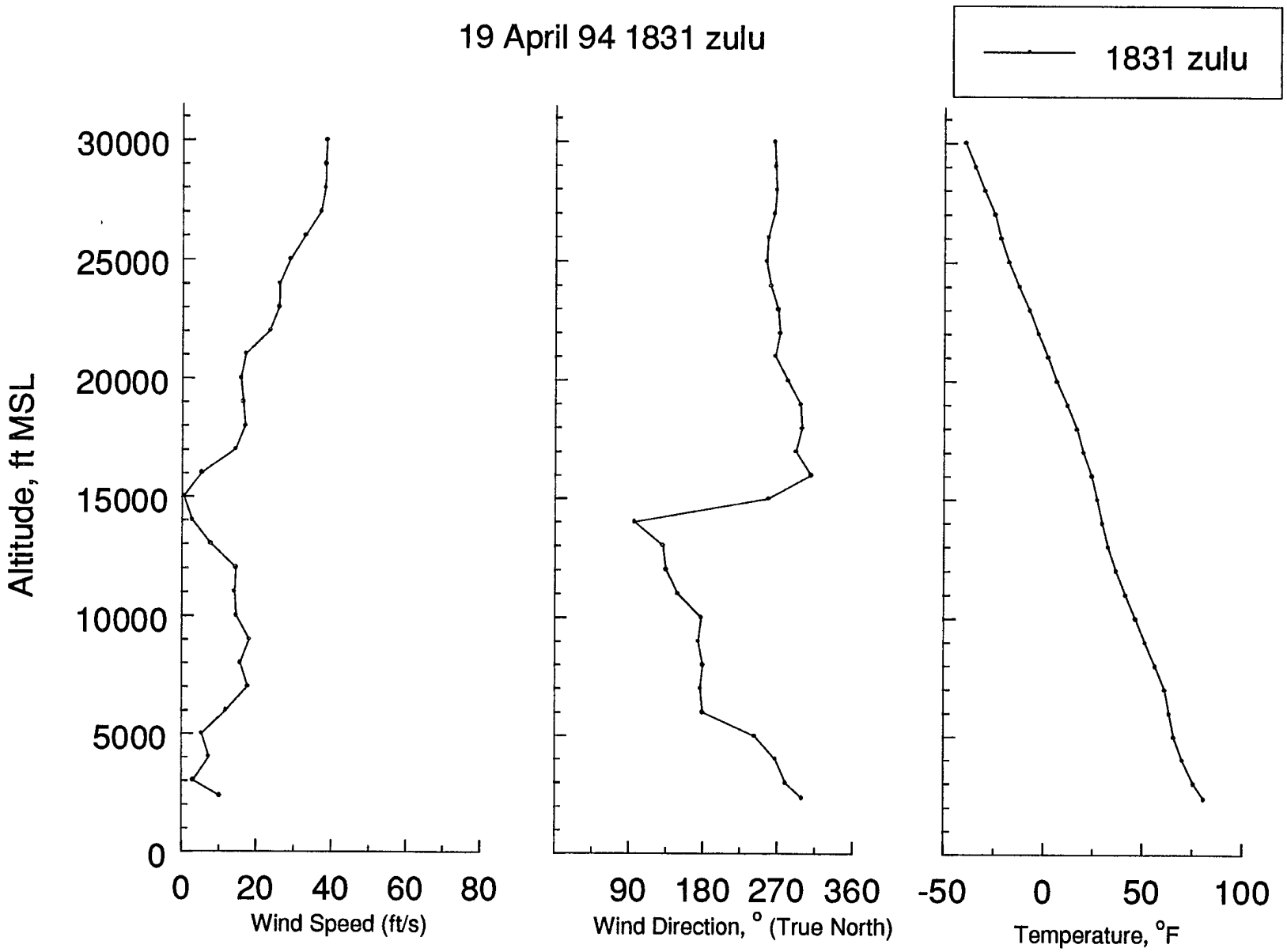

Figure B-5. Atmospheric profile for 19 April 1994

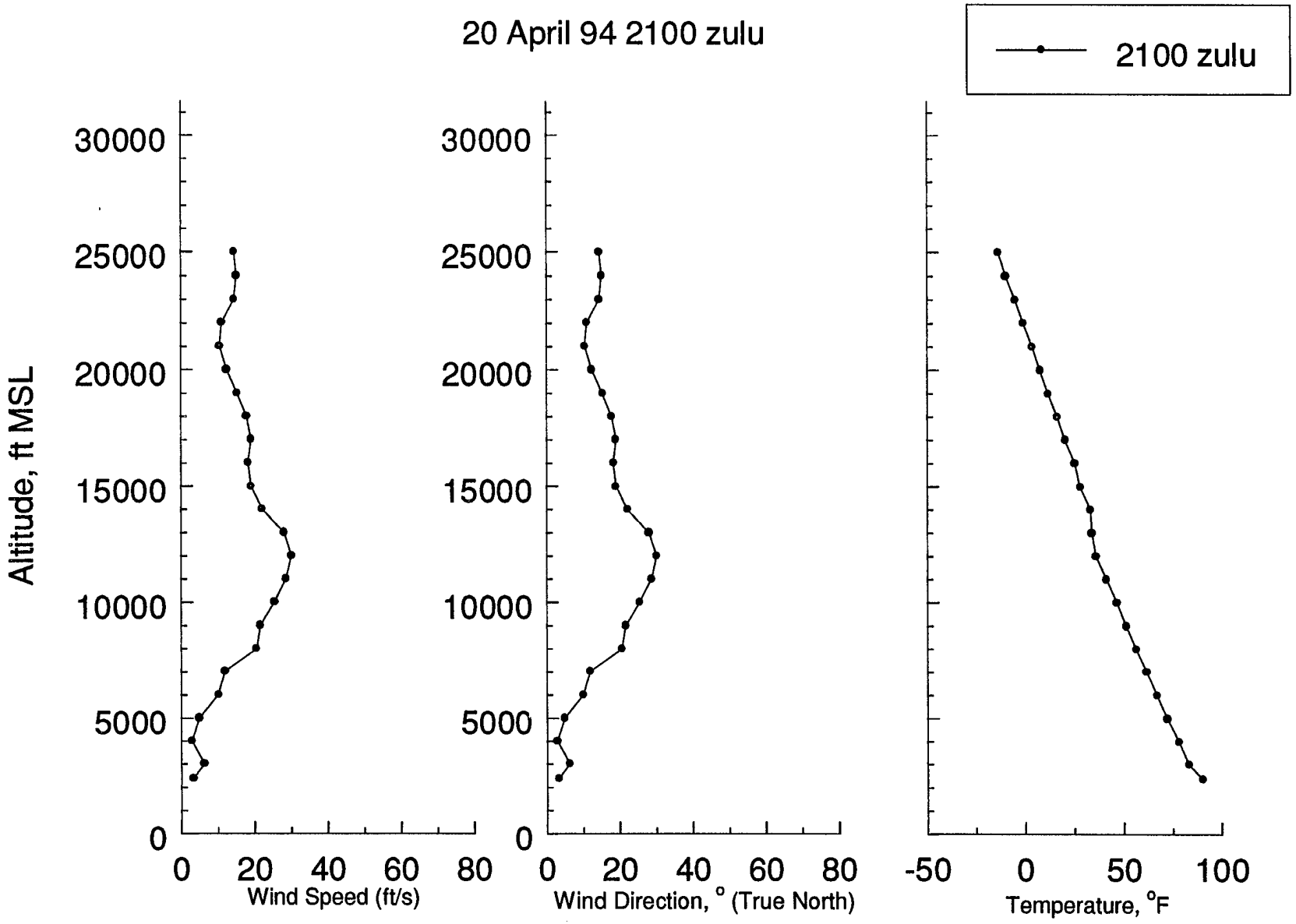

Figure B-6. Atmospheric profile for 20 April 1994

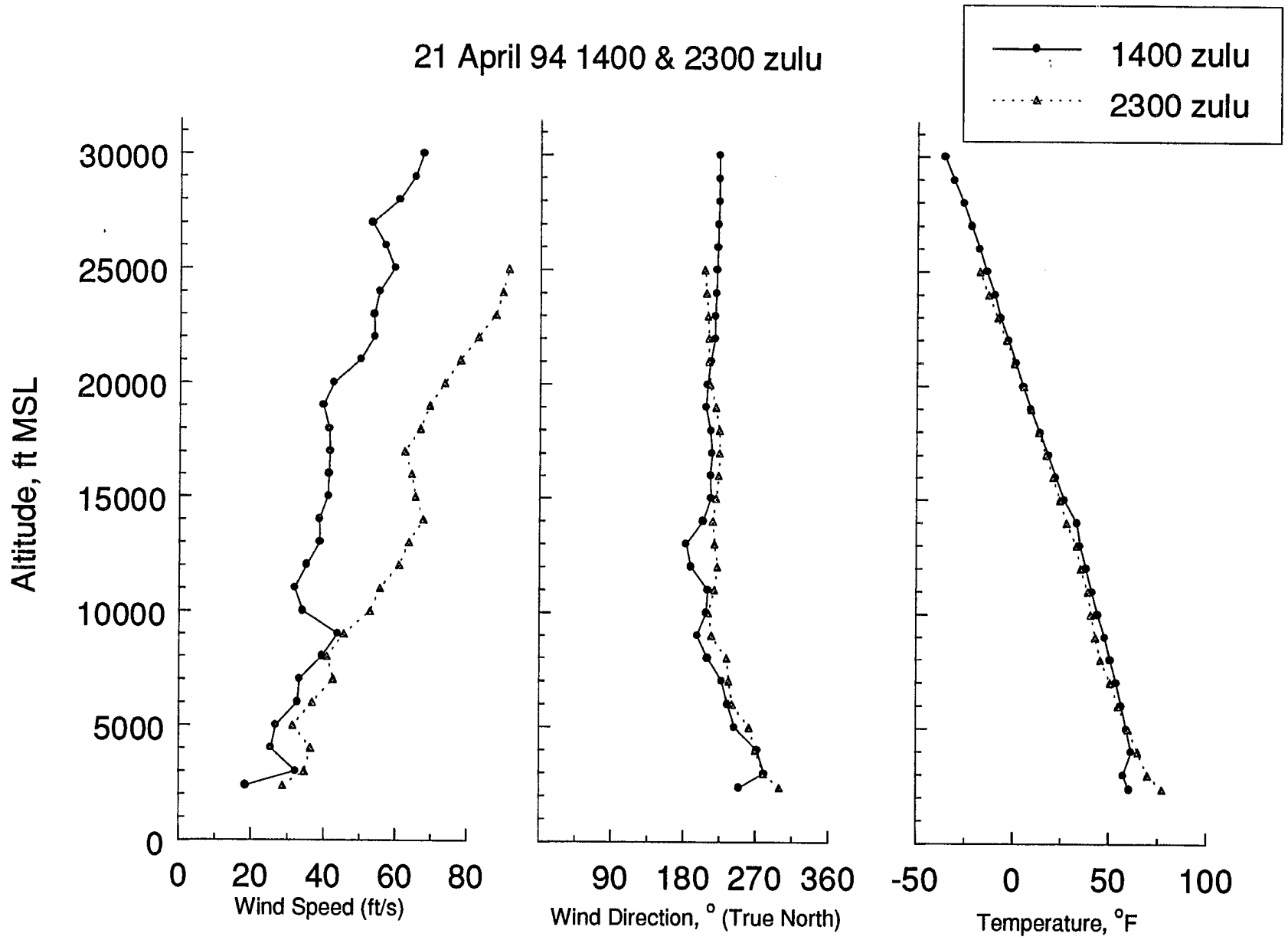

Figure B-7. Atmospheric profiles for 21 April 1994

Table C-1. Surface Weather Data for 12 April 1994

Time	Temperature, F			Wind			Relative Hunidity, %		
PDT	AVG	Low	High	Speed, kts	Direction T North	Gust, kts	AVG	Low	High
9:14:29	70.5	70.5	70.5	0.4	SE	1.1	16.5	16.5	16.5
9:15:00	70.5	70.5	70.5	0	N	0	16.5	16.5	16
9:16:00	70.5	70.5	70.5	0	N	0	16.5	16.5	16
9:17:00	70.5	70.5	70.5	0.8	WNW	1.5	16.5	17	16.5
9:18:00	70.5	70.5	70	1.7	SSE	2.5	17	17.5	17
9:19:00	70	70.5	70	3.2	WSW	5.9	17	17	17
9:20:00	70	70	70	1.7	WNW	4.8	17	17.5	17
9:21:00	70	70	70	1	WSW	1.5	16.5	17	16.5
9:22:00	70	70	70	1.3	NE	3.6	17	17	16.5
9:23:00	70	70	70	2.1	E	3.6	16.5	17	16.5
9:24:00	70	70	70	1.7	WNW	2.7	17	17	16.5
9:25:00	70	70	70	1.7	NNW	2.9	16.5	17	16.5
9:26:00	70	70	70	0.4	NNE	1	17	17	16.5
9:27:00	70.5	70.5	70	0.4	S	2.3	17	17	16.5
9:28:00	70.5	70.5	70.5	1	S	1.9	17	17	17
9:29:00	70.5	70.5	70.5	0	N	0	17	17.5	16.5
9:30:00	70.5	71	70.5	0.8	NNE	2.5	16.5	16.5	16
9:31:00	70.5	71	70.5	0.8	NE	2.3	16	16.5	15.5
9:32:00	71	71	70.5	0	N	0	16	16	15.5
9:33:00	71	71	71	0.6	ENE	1.7	16	16.5	16
9:34:00	71	71	71	0.6	ENE	1.3	15.5	16	15.5
9:35:00	71	71	71	1.9	NNE	2.7	15.5	16	15.5
9:36:00	70.5	71	70.5	2.9	S	4.6	16	16	15.5
9:37:00	70.5	70.5	70	1.9	NE	2.9	16	16.5	16
9:38:00	70	70.5	70	3.8	NNE	5.9	16.5	16.5	16
9:39:00	70	70	70	2.9	NNE	4.8	16.5	16.5	16
9:40:00	70	70	70	0.6	SSE	2.3	16.5	17	16.5
9:41:00	70	70.5	70	1.9	ENE	3.4	16.5	17	16.5
9:42:00	70.5	70.5	70	2.1	ENE	3.4	16.5	16.5	16
9:43:00	70.5	70.5	70.5	2.3	ENE	3.2	16.5	16.5	16
9:44:00	70.5	70.5	70.5	2.5	E	3	16.5	16.5	16
9:45:00	70.5	70.5	70.5	2.3	SE	2.3	16	16	16
11:57:57	69	69	68.5	4.4	SE	5.1	7	7	7
11:58:00	68.5	69	68.5	4.2	SE	5.3	7	7.5	7
11:59:00	68.5	68.5	68	3.4	SSW	7.2	7.5	7.5	7
12:00:00	68.5	68.5	68.5	7.2	S	13.5	7.5	7.5	7
12:01:00	68.5	69	68.5	5.3	SE	9.3	7.5	7.5	7
12:02:00	69	69	68.5	4.4	SSE	7.4	7	7.5	7
12:03:00	69	69	68.5	4	SE	5.5	7	7.5	7

Table C-1. Surface Weather Data for 12 April 1994, (continued)

Time	Temperature, F			Wind			Relative Hunidity, %		
PDT	AVG	Low	High	Speed, kts	Direction T North	Gust, kts	AVG	Low	High
12:04:00	69	69.5	69	6.1	SSE	9.3	7	7.5	7
12:05:00	69	69	68.5	5.5	SE	8.6	7	7.5	7
12:06:00	69	69	68.5	7.4	SE	10.5	7.5	7.5	7
12:07:00	68.5	69	68.5	7	SE	10.5	7	7.5	7
12:08:00	69	69	68.5	7.8	SSE	11.2	7.5	7.5	7
12:09:00	69	69	68.5	5	SE	8	7.5	7.5	7
12:10:00	69	69	68.5	5.7	SSE	8.9	7	7.5	7
12:11:00	69	69	68.5	5.5	SSE	8.9	7	7	7
12:12:00	69	69	68.5	3.8	S	7	7	7	7
12:13:00	69	69	68.5	5.9	SSE	9.3	7	7.5	7
12:14:00	69	69.5	69	4.8	SE	8.9	7	7	7
12:15:00	69.5	69.5	69	4.6	S	10.5	7	7	6.5
12:16:00	69.5	69.5	69	6.3	S	9.7	6.5	7	6.5
12:17:00	69.5	69.5	69	4	S	6.1	7	7	6.5
12:18:00	69.5	69.5	69	4.8	S	8.9	6.5	7	6.5
12:19:00	69.5	70	69.5	5	SSE	7.8	6.5	6.5	6.5
12:20:00	69.5	70	69.5	5.5	ESE	8	6	6.5	6
12:21:00	69	70	69	5.1	ESE	7.2	6.5	7	6
12:22:00	69	69.5	69	3.2	SSE	5.3	6.5	7	6.5
12:23:00	69.5	69.5	69	4.4	SE	7.6	6.5	6.5	6.5
12:24:00	69	69.5	68.5	7	S	9.9	6.5	7	6.5
12:25:00	69	69	68.5	3.6	S	8.9	7	7	7
12:26:00	69	69	69	6.5	SSE	10.7	6.5	7	6.5
12:27:00	69	69	68.5	5	S	8.4	6.5	7	6.5
12:28:00	68.5	69	68.5	5.5	S	10.1	7	7	6.5
12:29:00	68.5	69	68.5	6.5	SSW	10.3	6.5	7	6.5
12:30:00	69	69	68.5	5.3	SE	9.1	6.5	7	6.5
12:45:44	69	69	68.5	1.9	SSE	3.6	6.5	7	6.5
12:46:00	68.5	69	68.5	7.6	SE	11.8	6.5	7	6.5
12:47:00	68.5	68.5	68.5	6.5	SE	10.3	6.5	6.5	6.5
12:48:00	68.5	68.5	68	6.5	SSE	9.5	6.5	6.5	6.5
12:49:00	68.5	68.5	68	2.7	SSE	5.3	6.5	7	6.5
12:50:00	68.5	69	68.5	3.2	SE	7.2	6.5	6.5	6.5
12:51:00	68.5	69	68	5.5	E	8.6	6.5	7	6.5
12:52:00	68	68.5	67.5	4.6	E	8.9	7	7	6.5
12:53:00	67.5	68	67.5	5.3	ESE	10.5	7	7	7
12:54:00	67	67.5	67	5.3	ENE	8.8	7	7.5	7
12:55:00	67	67.5	66.5	5.1	E	9.7	7.5	7.5	7
12:56:00	66.5	66.5	66.5	2.3	SSE	3.8	7.5	8	7.5
12:57:00	66.5	67	66.5	2.3	SSW	4.2	7.5	8	7.5

Table C-1. Surface Weather Data for 12 April 1994, (continued)

Time	Temperature, F			Wind			Relative Hunidity, %		
PDT	AVG	Low	High	Speed, kts	Direction T North	Gust, kts	AVG	Low	High
12:58:00	67	67.5	66.5	4.4	SE	6.3	7.5	8	7.5
12:59:00	67.5	67.5	67	3.6	SSW	5.3	7	7.5	7
13:00:00	67.5	68	67.5	5	SSE	8.4	7	7.5	6.5
13:01:00	68	68	67.5	6.5	SSE	9.9	6.5	7	6.5
13:02:00	68	68.5	67.5	4.8	SE	10.1	6.5	7	6.5
13:03:00	68	68.5	68	6.1	SSE	9.5	6.5	6.5	6.5
13:04:00	68	68.5	68	3.6	SE	5	6.5	6.5	6.5
13:05:00	68.5	69	68	3.6	SE	6.1	6.5	7	6.5
13:06:00	68.5	69	68.5	3.4	SSE	6.5	6	6.5	6
13:07:00	68.5	69	68.5	3	S	5.9	6	6.5	6
13:08:00	68.5	69	68.5	1.3	SSE	2.1	6	6.5	6
13:09:00	69	69	68.5	3.6	ESE	5.7	6	6.5	6

Table C-2. Surface Weather Data for 13 April 1994

Time	Temperature, F			Wind			Relative Hunidity, %		
PDT	AVG	Low	High	Speed, kts	Direction T North	Gust, kts	AVG	Low	High
9:36:24	55.5	75	54	0.4	SE	1.1	21.5	37.5	20.5
9:37:00	54.5	55	54	2.1	S	4	21	21.5	21
9:38:00	54.5	55	54.5	2.7	SW	4	20.5	21	20.5
9:39:00	55	55.5	54.5	3	S	4.6	20.5	21	20.5
9:40:00	54.5	55	54.5	3.4	SE	4.4	20.5	21	20.5
9:41:00	54.5	55	54.5	2.7	SSW	4.4	21	21	20.5
9:42:00	54.5	55	54.5	4.6	SSE	6.1	20.5	21	20.5
9:43:00	54.5	55	54	3.2	SSE	4.8	20.5	21	20.5
9:44:00	54.5	55	54	3.2	SSE	5.7	20.5	21	20.5
9:45:00	54.5	55	54	3.4	SSE	5	20.5	20.5	20.5
9:46:00	54.5	55	54.5	2.3	SSW	4.2	20.5	20.5	20
9:47:00	54.5	55	54.5	1.3	SW	2.3	20.5	20.5	20
9:48:00	55	55	54.5	1.9	SE	4.8	20.5	20.5	20.5
9:49:00	55	55	54.5	2.9	S	5.1	20	20.5	20
9:50:00	55	55	54.5	1.9	S	3.8	20	20.5	20
9:51:00	55	55.5	54.5	2.9	SSW	5.3	20	20.5	20
9:52:00	55	55.5	55	2.9	SSE	4.6	20	20	19.5
9:53:00	55.5	55.5	55	3	SSE	4.6	20	20	19.5
9:54:00	55.5	55.5	55	1.7	SSE	3.6	20	20	19.5
9:55:00	55.5	55.5	55	1.3	S	3.8	19.5	20	19.5
9:56:00	55.5	55.5	55.5	3.6	SE	5.1	19.5	20	19.5
9:57:00	55.5	55.5	55	3.4	SSE	6.7	19.5	20	19.5
9:58:00	55.5	56	55.5	3.6	SSE	6.9	19.5	19.5	19
9:59:00	55.5	56	55.5	2.5	SE	4.6	19.5	19.5	19
10:00:00	55.5	56	55.5	2.3	SE	4.6	19	19.5	18.5
10:01:00	55.5	56	55.5	2.9	SSE	5.1	19	19.5	19
10:02:00	55.5	56	55.5	2.7	S	4.4	19	19.5	19
10:03:00	56	56	55.5	2.5	SE	5.3	19	19	18.5
10:04:00	56	56	55.5	3	SSE	5.5	18.5	19	18.5
10:05:00	56	56.5	55.5	2.3	S	3.4	19	19	18.5
10:06:00	56	56.5	56	2.1	SE	2.5	18.5	19	18.5
10:07:00	56	56.5	56	2.1	S	4.4	19	19	18.5
10:08:00	56	56.5	56	3.2	SSW	4.6	18.5	19	18.5
10:09:00	56	56.5	56	2.7	SE	3.6	18.5	19	18.5
10:10:00	56	56.5	56	3.4	SE	4.2	18.5	19	18.5
10:11:00	56	56.5	56	2.9	S	5.5	18.5	19	18.5
10:12:00	56	56.5	56	3.2	SSE	5.5	18.5	19	18.5
10:13:00	56	56.5	56	2.1	S	4	18.5	19	18.5
10:14:00	56	56.5	56	4	S	5.3	18	19	18
10:15:00	56.5	56.5	56	2.9	SSE	4.4	18	18.5	18

Table C-2. Surface Weather Data for 13 April 1994, (continued)

Time	Temperature, F			Wind			Relative Hunidity, %		
PDT	AVG	Low	High	Speed, kts	Direction T North	Gust, kts	AVG	Low	High
10:16:00	56.5	56.5	56	2.1	SW	3.6	18	18.5	18
10:17:00	56.5	56.5	56	3.2	SSW	4.8	18	18	17.5
10:18:00	56.5	56.5	56	1.7	SSW	2.9	17.5	18	17.5
10:19:00	56.5	57	56	1.7	NW	2.7	18	18	17.5
10:20:00	56.5	56.5	56	2.1	SSW	3.6	18	18.5	17.5
10:21:00	56.5	57	56.5	2.5	SE	4.8	18	18.5	17.5
10:22:00	56.5	57	56.5	1.5	SE	1.9	18	18	18
10:23:00	56.5	57	56.5	3	S	5.1	18	18	17.5
10:24:00	56.5	57	56.5	3.2	S	5.7	17.5	18	17.5
10:25:00	56.5	57	56.5	2.9	S	5	17.5	18	17.5
10:26:00	57	57	56.5	1.5	SW	4.8	18	18	17.5
10:27:00	57	57	57	2.3	SW	3.8	17	17.5	17
10:28:00	57	57	57	1.3	SW	3.6	17	17.5	17
10:29:00	57	57	57	4.2	S	6.7	17	17.5	17
10:30:00	57	57	57	2.5	SSE	4	17.5	17.5	17
10:31:00	57	57.5	57	2.1	SSE	3.6	17	17.5	17
10:32:00	57	57.5	57	1.5	SSW	2.5	17.5	17.5	17
10:33:00	57	57.5	57	0.8	SW	1.7	17	17.5	17
10:34:00	57.5	57.5	57	1.7	S	3.4	17	17.5	17
10:35:00	57.5	57.5	57.5	2.3	SSW	4.2	17	17	16.5
10:36:00	57.5	58	57.5	3	SSW	5	17	17	16.5
10:37:00	57.5	58	57.5	1.3	S	3.2	16.5	17	16.5
10:38:00	58	58	57.5	2.9	SSW	4.6	16.5	17	16.5
10:39:00	58	58.5	57.5	3.4	S	7.2	16.5	16.5	16
10:40:00	58	58	57.5	1.3	S	2.5	16.5	17	16
10:41:00	58	58.5	58	1	SW	2.5	16.5	16.5	16
10:42:00	58.5	58.5	58	0.2	SSW	1.1	16	16.5	16
10:43:00	58.5	58.5	58	3.4	SSW	6.3	16	16.5	16
10:44:00	58	58.5	58	3	S	4.2	16	16.5	16
10:45:00	58	58.5	58	3	SSW	3.6	16	16.5	16
13:31:28	63	63	63	2.3	NE	2.9	9.5	9.5	9.5
13:32:00	63	63	63	1.7	NNE	3	9.5	9.5	9.5
13:33:00	63	63	63	0.8	NNE	1.7	9.5	10	9.5
13:34:00	63	63.5	63	0.8	NNE	1.3	9.5	9.5	9
13:35:00	63.5	63.5	63	2.3	WSW	8	9.5	9.5	9
13:36:00	63.5	64	63.5	6.9	SSW	11.8	9.5	9.5	9.5
13:37:00	64	64	63.5	4	WSW	8.6	9.5	9.5	9.5
13:38:00	64	64	63.5	7	SW	11.2	9.5	9.5	9.5
13:39:00	64	64	63.5	4.8	W	8.2	9.5	9.5	9

Table C-2. Surface Weather Data for 13 April 1994, (continued)

Time	Temperature, F			Wind			Relative Hunidity, %		
PDT	AVG	Low	High	Speed, kts	Direction T North	Gust, kts	AVG	Low	High
13:40:00	64	64	64	6.9	WSW	9.7	9	9.5	9
13:41:00	64	64	64	5	WSW	8.2	9	9	9
13:42:00	64.5	64.5	64	4	WNW	7.8	9	9.5	8.5
13:43:00	64.5	64.5	64	6.1	WNW	10.1	8.5	9	8.5
13:44:00	64	64	63.5	4.4	W	7.2	9	9.5	9
13:45:00	64	64	63.5	4.2	WNW	7.4	9	9.5	9
13:46:00	64	64	63.5	4.6	NW	6.3	9	9	8.5
13:47:00	63.5	63.5	63.5	5.5	W	7.6	9	9.5	9
13:48:00	63.5	63.5	63.5	3.2	W	5.3	9	9.5	9
13:49:00	63.5	63.5	63.5	4.2	WNW	7.4	9.5	9.5	9
13:50:00	63.5	64	63.5	2.9	NW	4	9.5	9.5	9
13:51:00	63.5	64	63.5	2.3	WNW	5.5	9.5	9.5	9
13:52:00	63.5	63.5	63.5	4	WSW	6.9	9.5	9.5	9
13:53:00	63.5	64	63.5	3.6	NW	5.9	9.5	9.5	9
13:54:00	64	64	63.5	5.5	WSW	7.4	8.5	9.5	8
13:55:00	64	64	63.5	5.1	WSW	8.6	8.5	8.5	8.5
13:56:00	64.5	64.5	64	6.5	WSW	10.1	8	8.5	8
13:57:00	64.5	64.5	64	4.4	SSW	7	8	8.5	8
13:58:00	64.5	64.5	64.5	4.2	SSW	7	8	8.5	8
13:59:00	64.5	65	64.5	2.5	WSW	4.4	8	8.5	8
14:00:00	64.5	64.5	64	3.4	WSW	8.2	8.5	8.5	8
14:01:00	64	64.5	64	1.9	W	3.8	9	9	8.5
14:02:00	64	64	63.5	5.3	WNW	8.8	9	9	9
14:03:00	63.5	64	63.5	4.6	WNW	8	9	9	9
14:04:00	63.5	64	63.5	3.2	N	5	9	9.5	9
14:05:00	63.5	63.5	63	2.9	N	4.4	9.5	9.5	9.5
14:06:00	63.5	64	63.5	4.6	SW	8.8	9	9.5	8.5
14:07:00	64	64.5	64	4.4	SSW	7.4	8.5	9	8
14:08:00	64.5	64.5	64	1.7	SW	2.9	8.5	8.5	8
14:09:00	64.5	64.5	64	3.4	SE	6.5	8.5	8.5	8
14:10:00	64.5	64.5	64	3.2	SSE	5.7	8.5	8.5	8.5
14:11:00	64.5	65	64.5	5	SSE	8.6	8.5	8.5	8
14:12:00	64.5	65	64	6.3	S	8.4	8	8.5	8
14:13:00	64.5	64.5	64	4.4	S	5.9	8.5	8.5	8.5
14:14:00	64.5	64.5	64	3.8	W	8	8.5	9	8.5
14:15:00	64.5	64.5	64.5	5	SW	8	8.5	8.5	8.5
14:16:00	64.5	64.5	64.5	2.9	SSW	4	8.5	8.5	8
14:17:00	64.5	64.5	64.5	2.5	SW	4.8	8	8.5	8
14:18:00	64.5	65	64.5	2.5	SW	4.8	8	8	8
14:19:00	64.5	65	64.5	1.7	SW	3.2	8	8	7.5

Table C-2. Surface Weather Data for 13 April 1994, (continued)

Time	Temperature, F			Wind			Relative Hunidity, %		
PDT	AVG	Low	High	Speed, kts	Direction T North	Gust, kts	AVG	Low	High
14:20:00	64.5	65	64.5	1.7	SSW	6.1	7.5	8	7.5
14:21:00	65	65	64.5	3.6	SSW	6.3	7.5	7.5	7
14:22:00	65	65	64.5	4	SW	6.5	7	7.5	7
14:23:00	64.5	65	64.5	2.1	WSW	4	7.5	7.5	7.5
14:24:00	64.5	65	64.5	3	WSW	7.8	7.5	8	7.5
14:25:00	65	65	64.5	6.3	W	10.3	8	8	7.5
14:26:00	65	65.5	64.5	5.9	WSW	9.3	8	8	7.5
14:27:00	65.5	65.5	65.5	6.3	WSW	8.8	7.5	7.5	7
14:28:00	65.5	65.5	65.5	4.6	SW	8.6	7	7.5	7
14:29:00	65.5	65.5	65	5.3	SW	9.5	7.5	7.5	7
14:30:00	65	65.5	65	4.8	SSW	6.7	7.5	7.5	7.5
14:31:00	65	65	65	4.6	SSW	8.4	8	8	7.5
14:32:00	65	65	65	5.7	WSW	7.2	7	7.5	7
14:33:00	65	65	64.5	2.3	SW	5.5	7.5	7.5	7
14:34:00	64.5	65	64.5	1.9	SSW	2.7	7.5	8	7.5
14:35:00	64.5	65	64.5	1.5	S	3.2	7.5	8	7.5
14:36:00	65	65	64.5	2.5	SSE	3.8	7.5	7.5	7.5

Table C-3. Surface Weather Data for 15 April 1994

Time	Temperature, F			Wind			Relative Hunidity, %		
PDT	AVG	Low	High	Speed, kts	Direction T North	Gust, kts	AVG	Low	High
12:11:18	66	66	65.5	7.8	SE	11.8	8	8	8
12:12:00	66	66	65.5	7.6	SE	12	8	8	8
12:13:00	65.5	66	65.5	8.8	SE	11.2	8	8.5	8
12:14:00	65.5	65.5	65.5	9.5	ESE	12.6	8	8.5	8
12:15:00	65.5	65.5	65.5	8.4	ESE	13.1	8	8.5	8
12:16:00	65.5	65.5	65	7.2	ESE	10.9	8.5	9	8
12:17:00	65.5	65.5	65	3.8	ENE	6.7	8.5	9	8
12:18:00	65	65.5	65	5.5	NE	7.8	8	8.5	8
12:19:00	65	65.5	65	5.7	ESE	11.8	8.5	8.5	8
12:20:00	65.5	65.5	65	8.4	E	11	8	8.5	8
12:21:00	65	65.5	65	6.7	ESE	9.9	8.5	8.5	8
12:22:00	65.5	65.5	65	5.1	SE	8.2	8	8.5	8
12:23:00	65.5	65.5	65	2.9	ESE	4	8	8.5	8
12:24:00	65.5	65.5	65	5	E	7	8	8.5	8
12:25:00	65.5	65.5	65.5	8.2	SE	14.5	8	8.5	8
12:26:00	65.5	65.5	65.5	8.6	ESE	12.2	8	8	8
12:27:00	65.5	66	65.5	7.8	E	11.6	8	8	7.5
12:28:00	66	66	65.5	5	ESE	7.8	7.5	8	7.5
12:29:00	66	66	65.5	5	SE	7	7.5	8	7.5
12:30:00	66	66	65.5	6.7	SE	11	7.5	8	7.5
12:31:00	66	66	65.5	6.9	ESE	9.7	8	8	7.5
12:32:00	66	66	66	5.7	ESE	7	7.5	8	7.5

Table C-4. Surface Weather Data for 18 April 1994

Time	Temperature, F			Wind			Relative Hunidity, %		
PDT	AVG	Low	High	Speed, kts	Direction T North	Gust, kts	AVG	Low	High
11:48:19	33	33	33	3.4	SSW	4.8	39.5	40.5	39
11:49:00	33	33	32.5	1.5	SW	3.2	39.5	39.5	39
11:50:00	33	33	32.5	2.3	SW	4.8	39.5	40	39
11:51:00	33	33.5	33	4.4	S	6.3	39	40	39
11:52:00	33	33.5	33	4	SSW	5.5	39	39.5	39
11:53:00	33.5	33.5	33	3	SSW	4.2	39	39.5	39
11:54:00	33.5	33.5	33.5	1.7	S	2.9	39.5	39.5	39
11:55:00	33.5	33.5	33.5	2.7	N	4.6	39	39.5	39
11:56:00	33.5	33.5	33	1.9	SW	3	39.5	39.5	39
11:57:00	33.5	33.5	33.5	2.5	SW	5.3	39	39.5	39
11:58:00	33.5	33.5	33.5	2.5	SW	3.6	38.5	39	38.5
11:59:00	33.5	34	33.5	2.9	SW	5.9	38.5	41	38.5
12:00:00	33.5	33.5	33.5	2.7	W	4.2	39	39	38.5
12:01:00	33.5	33.5	33.5	1.9	W	3.2	39	39.5	38.5
12:02:00	33.5	34	33.5	0.4	SSW	1.9	39	39.5	39
12:03:00	33.5	33.5	33.5	3.2	SW	5	39.5	40	39.5
12:04:00	33.5	33.5	33.5	3	SSW	5.3	39.5	40	39.5
12:05:00	33.5	33.5	33.5	2.1	SSW	5.5	40	40	39.5
12:06:00	33.5	33.5	33.5	3.6	SSW	6.1	39.5	40	39.5
12:07:00	33.5	33.5	33.5	2.7	SW	4	40	40	39.5
12:08:00	33.5	33.5	33.5	2.7	SW	4.2	39.5	40	39.5
12:09:00	33.5	33.5	33.5	1	SSW	1.9	39.5	40	39.5
12:10:00	33.5	33.5	33	0.4	SSE	1.1	40	40	39
12:11:00	33.5	33.5	33	1	SSE	1.5	39.5	40	39
12:12:00	33	33.5	33	0.4	SSW	1.7	39	39	38.5
12:13:00	33.5	33.5	33	1.7	SSW	3.8	39	39	38.5
12:14:00	33.5	33.5	33	2.7	S	6.1	38.5	39	38
12:15:00	33	33.5	33	3.6	S	7.8	38	38.5	38
12:16:00	33	33.5	33	3	ESE	4.6	38	38.5	38
12:17:00	33	33.5	33	3	SE	5.3	38	38.5	38
12:18:00	33	33.5	33	1.5	SSE	2.5	38.5	38.5	38.5

Table C-5. Surface Weather Data for 19 April 1994

Time	Temperature, F			Wind			Relative Hunidity, %		
PDT	AVG	Low	High	Speed, kts	Direction T North	Gust, kts	AVG	Low	High
12:07:56	91	91.5	91	1.7	W	1.9	20.5	21	20.5
12:08:00	90.5	91.5	90	2.5	WSW	3.2	21	22	20.5
12:09:00	90.5	91	90	1	ESE	3.2	21.5	22	21.5
12:10:00	90.5	91	90.5	2.5	ESE	3.4	21.5	22	21.5
12:11:00	90	90.5	90	1.9	E	2.7	22	22.5	22
12:12:00	90	90	89.5	0.8	ENE	1.7	22	22.5	22
12:13:00	89.5	90	89.5	0.2	SSW	1.1	22	22.5	22
12:14:00	90	90.5	90	3.4	WSW	5.3	21.5	22	21.5
12:15:00	90.5	90.5	90.5	3.8	SW	5.7	21	21.5	21
12:16:00	90.5	91	90.5	4.6	SW	7.2	21	21.5	20.5
12:17:00	91	91	90.5	5.1	SSW	7.4	21	21.5	21
12:18:00	91	91	91	3	SSW	5.7	21	21	21
12:19:00	91.5	91.5	91	2.9	S	4.4	20.5	21	20.5
12:20:00	91.5	91.5	91.5	2.1	S	3.8	20.5	20.5	20
12:21:00	91	91.5	91	2.1	SW	4	20.5	20.5	20
12:22:00	91	91	91	0.6	ESE	2.1	20.5	20.5	20.5
12:23:00	91	91	90.5	2.5	E	4.4	20.5	21	20.5
12:24:00	90.5	90.5	90.5	1.1	SE	3.2	21	21.5	21
12:25:00	90.5	90.5	90.5	2.3	SE	3.4	21	21.5	21
12:26:00	90.5	90.5	90.5	2.1	ESE	3.6	21.5	22	21
12:27:00	90.5	90.5	90	2.3	SE	3.2	21.5	21.5	21
12:28:00	90.5	90.5	90	2.7	S	4.6	21.5	22	21.5
12:29:00	90.5	91	90.5	3.6	SSW	5.5	21.5	21.5	21.5
12:30:00	91	91.5	91	4.6	SSE	6.9	21	21.5	20.5

Table C-6. Surface Weather Data for 20 April 1994

Time	Temperature, F			Wind			Relative Hunidity, %		
PDT	AVG	Low	High	Speed, kts	Direction T North	Gust, kts	AVG	Low	High
14:46:11	96	96	95.5	1.1	SSE	2.3	8.5	9	8.5
14:47:00	95.5	96	95.5	2.1	S	5.1	9	9	8.5
14:48:00	96	96.5	96	4.8	S	7	8.5	8.5	8
14:49:00	96	96	96	5.5	WSW	11.8	8.5	8.5	8
14:50:00	96.5	96.5	96	5.5	SW	8.4	8	8.5	8
14:51:00	96.5	97	96.5	6.1	SW	8.8	8	8.5	7.5
14:52:00	97	97	97	4.6	SW	7.4	8	8	7.5
14:53:00	97.5	97.5	97	5.7	WSW	9.9	7.5	8	7.5
14:54:00	97.5	97.5	97.5	6.1	SSW	9.3	7.5	8	7.5
14:55:00	97.5	98	97.5	5.7	W	8	7.5	7.5	7.5
14:56:00	97.5	98	97.5	7.2	W	9.5	7.5	7.5	7.5
14:57:00	97.5	97.5	97.5	4.2	W	7	7.5	8	7.5
14:58:00	97	97.5	96.5	4.2	WNW	5.5	7.5	8	7.5
14:59:00	96.5	97	96.5	1.3	W	4.8	8	8	8
15:00:00	96.5	96.5	96	2.9	WNW	7.4	8	8.5	8
15:01:00	96	96.5	96	4.6	WNW	7	8	8.5	8
15:02:00	96	96	96	4.6	N	8.6	8	8.5	8
15:03:00	96	96	96	5.1	WNW	7.2	8	8.5	8
15:04:00	95.5	96	95.5	4	NW	5.7	8.5	8.5	8
15:05:00	95.5	95.5	95.5	3.2	WNW	5.5	8.5	8.5	8.5
15:06:00	95.5	96	95.5	2.1	NNW	4.8	8.5	8.5	8
15:07:00	95.5	96	95.5	3	SW	6.5	8	8.5	8
15:08:00	96	96	95.5	5	WSW	8.9	8	8.5	8
15:09:00	96	96.5	96	6.9	WSW	10.7	8	8	8
15:10:00	96.5	96.5	96	7.2	WSW	9.7	8	8	8
15:11:00	96	96.5	96	7	WSW	9.1	8	8	8
15:12:00	96	96	96	1	W	3	8	8	8
15:13:00	96	96.5	96	3	NE	4.6	8	8	8
15:14:00	95.5	96	95	2.5	NW	3	8.5	8.5	8
15:15:00	95	95.5	95	1.7	WNW	2.5	8.5	8.5	8.5
15:16:00	95.5	95.5	95	4.4	NNW	8.4	8.5	8.5	8
15:17:00	95.5	95.5	95	4.4	NW	6.5	8.5	8.5	8
15:18:00	95.5	96	95	4.6	WNW	8	8.5	8.5	8
15:19:00	95.5	96	95.5	6.3	W	8.6	8	8	8
15:20:00	95.5	96	95.5	7	W	10.3	8	8	8
15:21:00	95.5	96	95.5	5.3	W	9.5	8	8	8
15:22:00	96	96	95.5	7.6	W	10.7	8	8	8
15:23:00	95.5	95.5	95.5	5.1	WSW	7.2	8	8	8
15:24:00	95.5	95.5	95	2.9	W	6.5	8	8	8
15:25:00	95.5	95.5	95	0.8	WSW	2.5	8	8.5	8

Table C-6. Surface Weather Data for 20 April 1994, (continued)

Time	Temperature, F			Wind			Relative Hunidity, %		
PDT	AVG	Low	High	Speed, kts	Direction T North	Gust, kts	AVG	Low	High
15:26:00	95.5	96	95.5	3.2	SW	4.6	8	8.5	8
15:27:00	96	96	95.5	5.5	NW	8.6	8	8	8
15:28:00	96	96	95.5	3.2	WNW	5	8	8	8
15:29:00	95.5	96	95.5	2.7	NW	4.2	8	8	8
15:30:00	95.5	96	95.5	1.3	NNW	2.5	8	8	8
15:31:00	96	96	95.5	4.2	W	5.5	7.5	8.5	7.5
15:32:00	96	96.5	96	4	WNW	7.2	7.5	7.5	7.5
15:33:00	96.5	96.5	96	5	WNW	7	7.5	7.5	7.5
15:34:00	96.5	96.5	96.5	5.7	WSW	8.4	7.5	7.5	7.5
15:35:00	96.5	96.5	96	4.2	W	7.2	7.5	8	7.5
15:36:00	97	97	96.5	4.6	W	6.9	7.5	7.5	7.5
15:37:00	97	97	96.5	5.1	NW	8	7.5	7.5	7
15:38:00	96.5	97	96.5	5.7	W	7.6	7.5	7.5	7.5
15:39:00	96.5	96.5	96.5	5.9	NNW	8	7.5	7.5	7.5
15:40:00	96	96.5	96	5.5	NNW	8.4	8	8	7.5
15:41:00	96.5	96.5	96	6.1	NNW	10.3	7.5	8	7.5
15:42:00	96	96.5	96	5.7	NW	8.8	8	8	7.5
15:43:00	96	96.5	96	2.7	WNW	4.4	8	8	7.5
15:44:00	97	97	96.5	4.8	WSW	8.8	7.5	8	7.5
15:45:00	97	97	96.5	5.1	WSW	8.2	7.5	7.5	7.5
15:46:00	97	97	96.5	2.7	SW	5.9	7.5	8	7.5
15:47:00	97	97	97	4.6	WSW	9.1	7.5	8	7.5
15:48:00	97	97	96.5	5.7	WSW	7.4	7.5	7.5	7.5
15:49:00	96.5	97	96.5	4	W	7	7.5	8	7.5
15:50:00	96.5	97	96.5	2.5	NW	4.6	8	8	7.5
15:51:00	96.5	97	96.5	5.5	SW	8	8	8	7.5
15:52:00	96.5	96.5	96.5	4.2	WSW	5.7	8	8	7.5
15:53:00	96.5	96.5	96.5	2.9	WSW	3.8	8	8	7.5
15:54:00	96.5	97	96.5	3.6	NW	5.3	7.5	8	7.5
15:55:00	96	96.5	96	2.5	NNW	4.2	8	8	7.5
15:56:00	96.5	96.5	96	0.8	NNW	1.9	8	8	8
15:57:00	96.5	96.5	96	1.9	NNW	3	8	8	7.5
15:58:00	96	96	96	1.1	NE	4.2	8	8	8
15:59:00	96	96	95.5	3.2	NE	4.4	8	8	8
16:00:00	95.5	96	95.5	4.2	ENE	5.5	8	8	7.5
16:01:00	95.5	95.5	95.5	2.5	ENE	3.4	8	8	7.5
16:02:00	95.5	95.5	95.5	2.1	N	2.7	8	8	7.5
16:03:00	95.5	95.5	95.5	2.3	NW	3.6	7.5	8	7.5
16:04:00	96	96	95.5	2.1	NW	5	7.5	8	7.5
16:05:00	96.5	97	96	5	WSW	7.6	8	8	7.5

Table C-6. Surface Weather Data for 20 April 1994, (continued)

Time	Temperature, F			Wind			Relative Hunidity, %		
PDT	AVG	Low	High	Speed, kts	Direction T North	Gust, kts	AVG	Low	High
16:06:00	97	97	96.5	4	SSW	6.7	7.5	8	7.5
16:07:00	97	97.5	97	3.2	SW	5.1	7.5	8	7.5
16:08:00	97.5	97.5	97.5	3.4	SW	3.2	7.5	7.5	7.5

Table C-7. Surface Weather Data for 21 April 1994

Time	Temperature, F			Wind			Relative Hunidity, %		
PDT	AVG	Low	High	Speed, kts	Direction T North	Gust, kts	AVG	Low	High
7:14:37	59.5	59.5	59.5	1.9	SE	2.9	56.5	57	56.5
7:15:00	59.5	60	59.5	1.5	SSE	2.3	56.5	57	56.5
7:16:00	60	60	60	1	SE	1.9	56.5	56.5	56
7:17:00	60	60.5	60	2.1	SSE	4.2	56	56	55.5
7:18:00	60.5	60.5	60	2.7	SSE	3	55.5	56	55.5
7:19:00	60.5	60.5	60.5	2.9	SSE	4.2	55.5	55.5	55.5
7:20:00	60.5	60.5	60.5	3	SSE	5	55.5	55.5	55
7:21:00	60.5	60.5	60.5	3.4	SE	4.4	55	55	55
7:22:00	60.5	60.5	60.5	3	SSE	4.8	55	55	54.5
7:23:00	60.5	60.5	60.5	2.5	SSE	3.8	54.5	55	54
7:24:00	60.5	60.5	60.5	2.3	S	3.6	54	54.5	53.5
7:25:00	60.5	60.5	60.5	3.2	SSE	4.4	53.5	54	53.5
7:26:00	60.5	60.5	60.5	2.7	S	4.2	53.5	53.5	53.5
7:27:00	60.5	61	60.5	2.7	S	4.6	53.5	53.5	53
7:28:00	60.5	61	60.5	4	SSE	5.3	52.5	53	52.5
7:29:00	60.5	60.5	60.5	3.2	SE	4.6	53	53	52.5
7:30:00	60.5	60.5	60.5	3	SSE	4.6	53	53	53
7:31:00	61	61	60.5	3.2	SSE	4.4	52.5	53	52.5
7:32:00	61	61	60.5	3	S	4.6	53	53	52.5
7:33:00	61	61	61	2.5	S	3.6	52	52.5	52
7:34:00	61	61	61	2.3	S	3.4	52	52.5	52
7:35:00	61.5	61.5	61	1.7	S	3.4	52	52	51.5
7:36:00	61.5	61.5	61.5	2.3	SSE	4.4	51	51.5	51
7:37:00	61.5	61.5	61.5	3	S	5	51	51	50.5
7:38:00	61.5	61.5	61.5	3.2	SSE	5.5	50.5	50.5	50
7:39:00	61.5	61.5	61.5	2.3	S	4.6	50	50.5	50
7:40:00	61.5	62	61.5	2.3	S	4.6	50	50.5	49.5
7:41:00	62	62	61.5	2.9	S	4.4	49.5	50	49.5
7:42:00	62	62	61.5	3.2	SSE	5.3	50	50	49.5
7:43:00	62	62	61.5	3.2	S	4.8	49.5	50	49.5
7:44:00	62	62	61.5	2.7	S	4	49.5	50	49.5
7:45:00	62	62	62	2.9	SSE	5.1	49.5	49.5	49
7:46:00	62	62	62	3	S	5.1	48.5	49	48.5
7:47:00	62	62.5	62	2.1	SSW	3.4	48.5	49	48.5
7:48:00	62.5	62.5	62.5	2.9	S	4.2	48.5	48.5	48
7:49:00	62.5	62.5	62.5	2.3	S	3.8	48	48.5	48
7:50:00	62.5	62.5	62.5	2.3	SSW	3.8	47.5	48	47.5
7:51:00	62.5	63	62.5	2.3	S	4	47.5	48	47.5
7:52:00	63	63	62.5	2.3	SSW	3.8	47.5	47.5	47
7:53:00	63	63	63	2.5	S	3.6	47	47.5	46.5

Table C-7. Surface Weather Data for 21 April 1994, (continued)

Time	Temperature, F			Wind			Relative Hunidity, %		
PDT	AVG	Low	High	Speed, kts	Direction T North	Gust, kts	AVG	Low	High
7:54:00	63	63	63	2.3	S	3.8	46.5	47	46.5
7:55:00	63	63	63	2.3	S	3.8	46.5	47	46
7:56:00	63.5	63.5	63	3.6	SSW	5.3	46	46.5	45.5
7:57:00	63	63.5	63	2.3	SSW	3.6	46	46	45.5
7:58:00	63	63.5	63	3.8	SSW	5.1	46	46	45.5
7:59:00	63	63	63	2.9	S	4.8	46	46.5	46
8:00:00	63.5	63.5	63	1.9	SSE	4.4	45.5	46	45.5
8:01:00	63.5	63.5	63.5	2.3	S	3.4	45.5	46	45
8:02:00	63.5	64	63.5	2.3	SSW	3.4	45	45	44.5
8:03:00	64	64	63.5	1.7	SSW	3.6	44.5	45	43.5
8:04:00	64.5	64.5	64	2.1	S	4.4	43	44	42.5
8:05:00	64.5	64.5	64.5	2.1	S	4	42.5	43	42.5
8:06:00	64.5	64.5	64	3.6	S	4.8	42.5	42.5	42
8:07:00	64.5	64.5	64	3	S	4	42.5	43	42.5
16:12:26	84	84	84	10.9	WSW	14.3	11.5	12	11.5
16:13:00	84.5	84.5	84	9.3	W	17.3	12	12	11.5
16:14:00	84	84.5	84	9.5	W	15.2	12.5	12.5	12
16:15:00	84	84	84	10.3	WSW	16.2	12	12	11.5
16:16:00	84	84.5	84	12	SW	17.9	11.5	11.5	11
16:17:00	84	84.5	84	10.1	W	14.5	11	11	11
16:18:00	84	84.5	84	12.2	W	19.2	11	11	10.5
16:19:00	84.5	84.5	84	12	WSW	18.1	11	11.5	10.5
16:20:00	84	84	84	11	WSW	17.9	10.5	11	10.5
16:21:00	84	84	84	10.9	WSW	16	11.5	11.5	11
16:22:00	84	84	84	8.4	WSW	13.7	11.5	11.5	11.5
16:23:00	84	84	84	11	WSW	14.8	11	11.5	11
16:24:00	84	84	84	10.9	WSW	16.2	11.5	12	11
16:25:00	84	84	84	10.5	W	15.2	12	12	12
16:26:00	84	84.5	84	8.9	W	13.9	12	12	11.5
16:27:00	84.5	84.5	84	11.4	SW	16.8	12	12	12
16:28:00	84.5	84.5	84	11.8	WSW	17.9	12	12.5	12
16:29:00	84	84.5	84	10.5	W	15.6	12	12.5	12
16:30:00	84	84.5	84	11.2	WSW	17.7	12.5	12.5	12
16:31:00	84	84.5	84	12.4	WSW	17.7	12	12.5	12
16:32:00	84	84	83.5	9.9	W	13.9	13	13	12.5
16:33:00	83.5	83.5	83.5	8.9	SW	14.5	13.5	13.5	13
16:34:00	83.5	83.5	83.5	12.4	SW	17.7	13	13.5	13
16:35:00	83.5	83.5	83	10.7	WSW	16.4	13	13.5	13
16:36:00	83	83	82.5	12	W	16.2	13.5	14	13.5

Table C-7. Surface Weather Data for 21 April 1994, (continued)

Time	Temperature, F			Wind			Relative Hunidity, %		
PDT	AVG	Low	High	Speed, kts	Direction T North	Gust, kts	AVG	Low	High
16:37:00	82.5	82.5	82.5	13.7	WSW	19	14	14	13.5
16:38:00	82.5	82.5	82.5	12.8	WSW	17.1	14	14	14
16:39:00	82.5	82.5	82	13.5	W	21.7	14	14	14
16:40:00	82	82	82	12	WSW	16.6	14	14.5	14
16:41:00	82	82.5	82	11.2	WSW	17.3	14	14.5	14
16:42:00	82	82	81.5	8.6	WNW	12.6	14.5	14.5	14
16:43:00	81.5	82	81.5	7.2	WSW	13.1	14.5	14.5	14.5
16:44:00	82	82	82	13.5	WSW	20	14.5	14.5	14.5
16:45:00	82	82	82	11.4	WSW	16.6	14.5	15	14.5
16:46:00	82	82	81.5	10.1	W	15.8	14.5	15	14.5
16:47:00	81.5	81.5	81.5	14.3	W	19.8	14.5	15	14.5
16:48:00	81.5	81.5	81.5	14.1	WSW	19.4	14.5	15	14.5
16:49:00	81.5	81.5	81.5	12.6	WSW	17.5	15	15	14.5
16:50:00	81.5	81.5	81.5	11	WSW	16.2	15	15	14.5
16:51:00	81.5	81.5	81.5	10.7	SW	17.7	15	15	15
16:52:00	81.5	81.5	81.5	10.3	WSW	16.8	15	15	15
16:53:00	81	81.5	81	11.4	WSW	16.2	15	15	15
16:54:00	81	81	81	12.2	WNW	19	15	15.5	15
16:55:00	81	81	81	10.9	SW	18.8	15.5	15.5	15.5
16:56:00	81	81	81	7.8	W	12.6	15	15.5	15
16:57:00	81	81.5	81	11.6	WSW	21.5	15	15	15
16:58:00	81	81.5	81	13.3	W	20.8	15	15	15
16:59:00	81	81.5	81	13.3	SW	17.9	14.5	15	14.5
17:00:00	81	81	81	12.6	WSW	19.8	15	15	14.5
17:01:00	81	81	80.5	14.5	WSW	20.4	15	15	15
17:02:00	80.5	81	80.5	12.4	W	18.5	15	15.5	15
17:03:00	80.5	80.5	80.5	13.9	W	20.8	15.5	15.5	15.5
17:04:00	80.5	81	80.5	12.9	SW	20.4	15.5	15.5	15.5
17:05:00	80.5	81	80.5	10.5	WSW	15.8	16	16	15.5
17:06:00	81	81	80.5	10.9	WSW	17.5	15.5	16	15.5
17:07:00	81	81	81	12.2	W	18.5	15.5	15.5	15.5
17:08:00	80.5	81	80.5	12	WSW	17.9	15.5	15.5	15.5
17:09:00	80.5	81	80.5	10.7	WSW	17.1	15.5	15.5	15.5
17:10:00	81	81	81	10.9	W	17.3	15.5	15.5	15.5
17:11:00	81	81	81	10.5	W	15	15.5	15.5	15.5
17:12:00	81	81	80.5	13.9	W	21.5	16	16	15.5
17:13:00	80.5	80.5	80	12.9	W	18.5	16	16.5	16
17:14:00	80	80.5	80	11	WSW	19.4	16.5	16.5	16
17:15:00	80	80.5	80	13.7	WSW	18.3	16	16.5	16
17:16:00	80	80	80	12.2	WSW	18.5	16.5	16.5	16

Table C-7. Surface Weather Data for 21 April 1994, (continued)

Time	Temperature, F			Wind			Relative Hunidity, %		
PDT	AVG	Low	High	Speed, kts	Direction T North	Gust, kts	AVG	Low	High
17:17:00	80	80	79.5	12.2	WSW	20.2	16.5	16.5	16.5
17:18:00	79.5	80	79.5	12	W	20.8	16.5	16.5	16.5
17:19:00	80	80	79.5	11.2	WSW	18.5	16.5	16.5	16.5
17:20:00	80	80	80	11	W	16.6	16.5	16.5	16
17:21:00	80	80	80	11.6	WSW	17.1	16.5	16.5	16
17:22:00	80	80	80	9.7	WSW	18.3	16.5	16.5	16
17:23:00	80	80	80	11.2	WSW	20	16.5	16.5	16
17:24:00	79.5	80	79.5	12.8	WNW	19.6	16.5	17	16.5
17:25:00	79.5	79.5	79.5	12.8	W	18.7	17	17	16.5
17:26:00	79.5	79.5	79	13.5	W	19.2	17	17	17
17:27:00	79.5	79.5	79	11.8	W	20.8	17	17	16.5
17:28:00	79	79.5	79	15.4	WSW	23.6	17	17	16.5
17:29:00	79	79.5	79	13.7	W	18.5	17	17	17
17:30:00	79	79	79	12.8	WSW	19	17	17.5	17
17:31:00	79	79	79	12.4	W	20	17.5	17.5	17
17:32:00	79	79	79	9.9	SW	16	17.5	17.5	17
17:33:00	79	79.5	79	11.4	WSW	15.8	17	17.5	17
17:34:00	79	79.5	79	12.2	WSW	19.8	17.5	17.5	17
17:35:00	79	79	79	14.3	WSW	20.8	17.5	18	17.5
17:36:00	78.5	79	78.5	12.4	WSW	19	18	18	18
17:37:00	78.5	78.5	78.5	12.4	WSW	19.2	18	18.5	18
17:38:00	78.5	78.5	78	13.7	W	19.8	18.5	18.5	18
17:39:00	78.5	78.5	78	11	WNW	18.5	18.5	18.5	18.5
17:40:00	78	78.5	78	9.1	WNW	16.6	18.5	18.5	18.5
17:41:00	78.5	78.5	78	11.8	W	18.3	18.5	18.5	18.5
17:42:00	78	78	78	9.5	W	14.3	18.5	19	18.5
17:43:00	78	78.5	78	11.8	W	19.2	18.5	18.5	18.5
17:44:00	78	78.5	78	12.2	W	16.8	18.5	19	18.5
17:45:00	78	78	78	10.5	W	16.9	19	19	19
17:46:00	78	78	77.5	14.1	W	20	19	19.5	19
17:47:00	78	78	77.5	9.5	W	17.1	19	19.5	19
17:48:00	78	78	78	0	N	0	19.5	19.5	19

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APPENDIX C: SONIC BOOM SIGNATURES

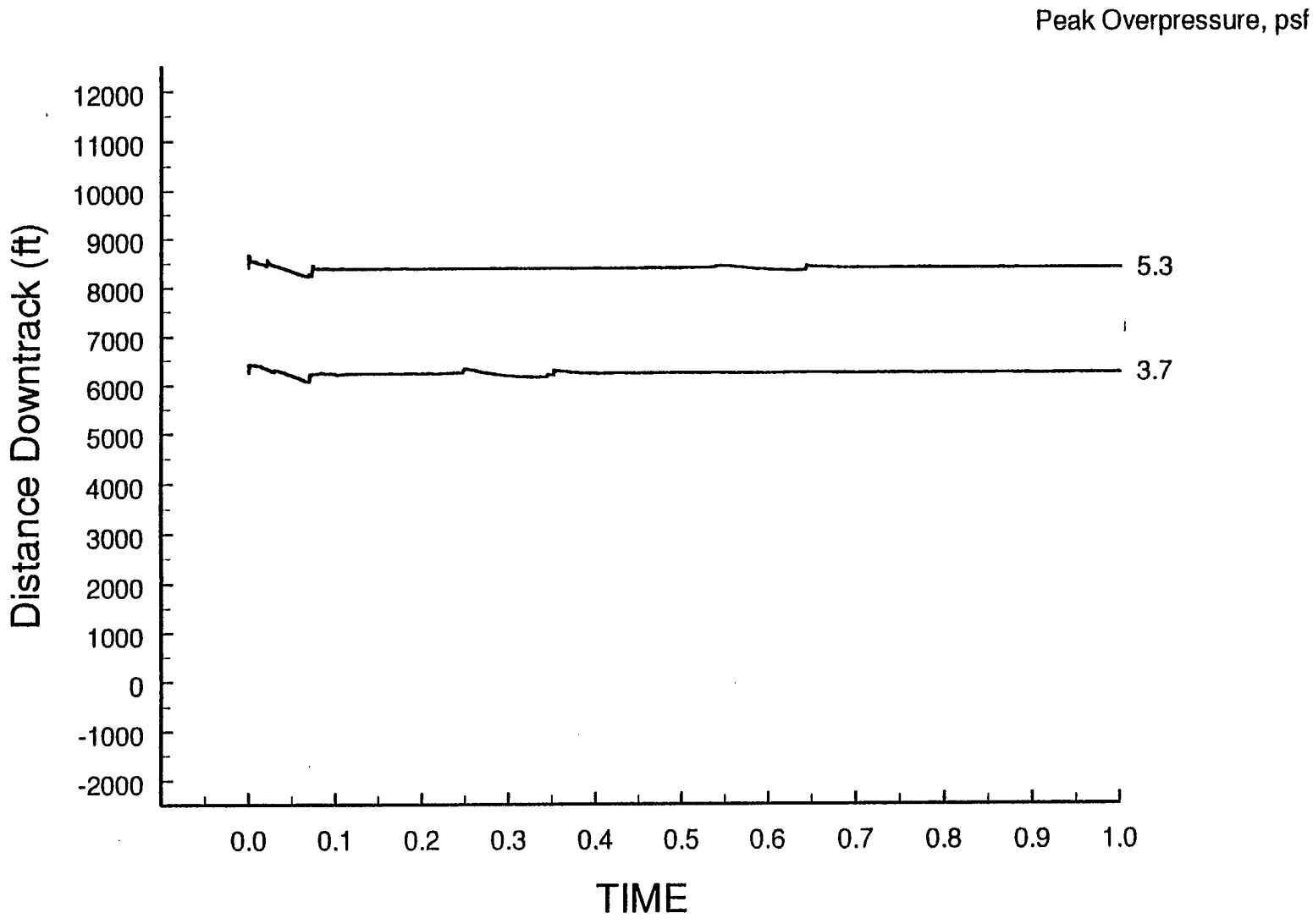

Figure C-1 Sonic boom signatures from pass 16, 30° diving acceleration.

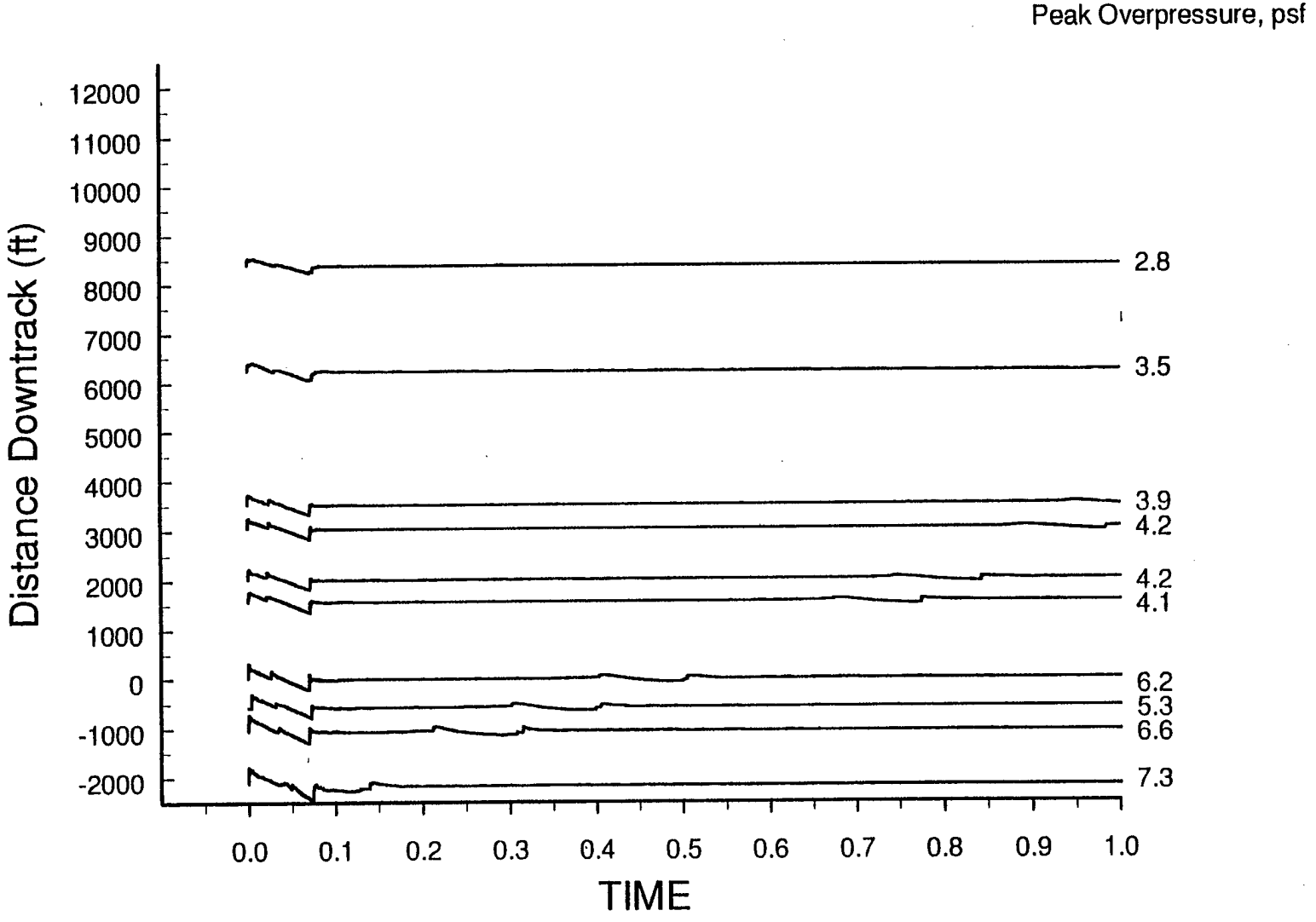

Figure C-2 Sonic boom signatures from pass 17, 30° diving acceleration

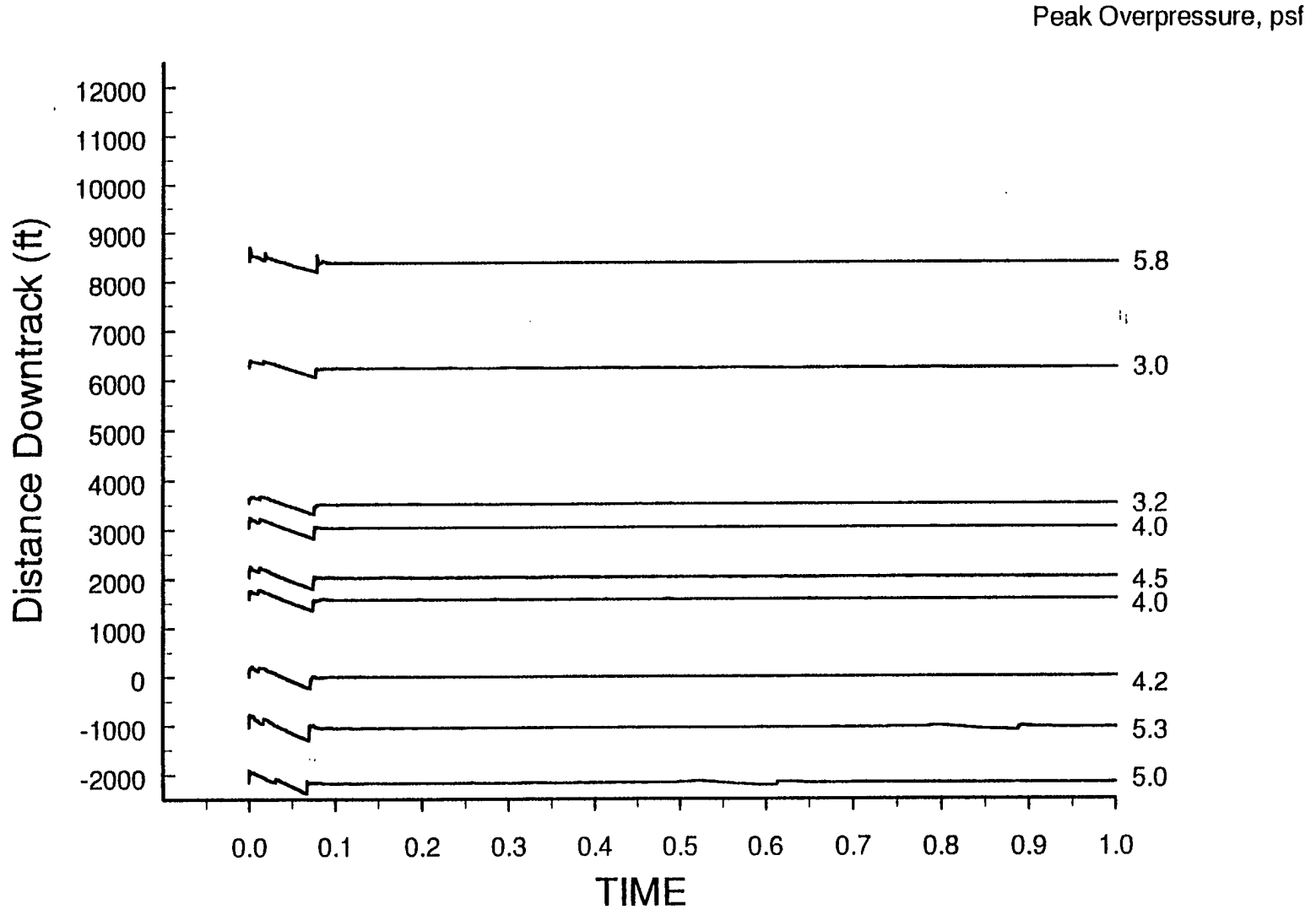

Figure C-3 Sonic boom signatures from pass 18, 30° diving acceleration

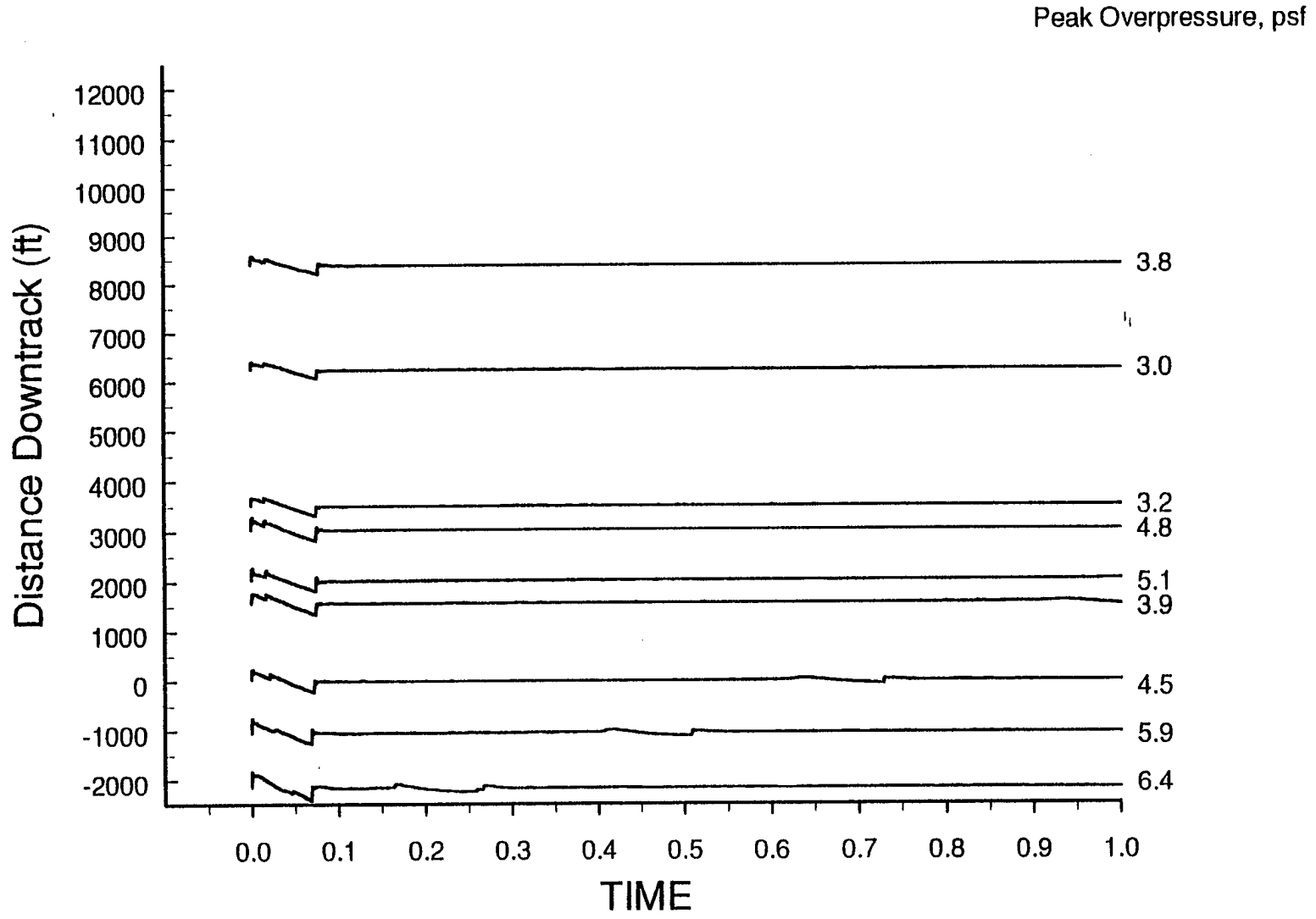

Figure C-4 Sonic boom signatures from pass 19, 30° diving acceleration

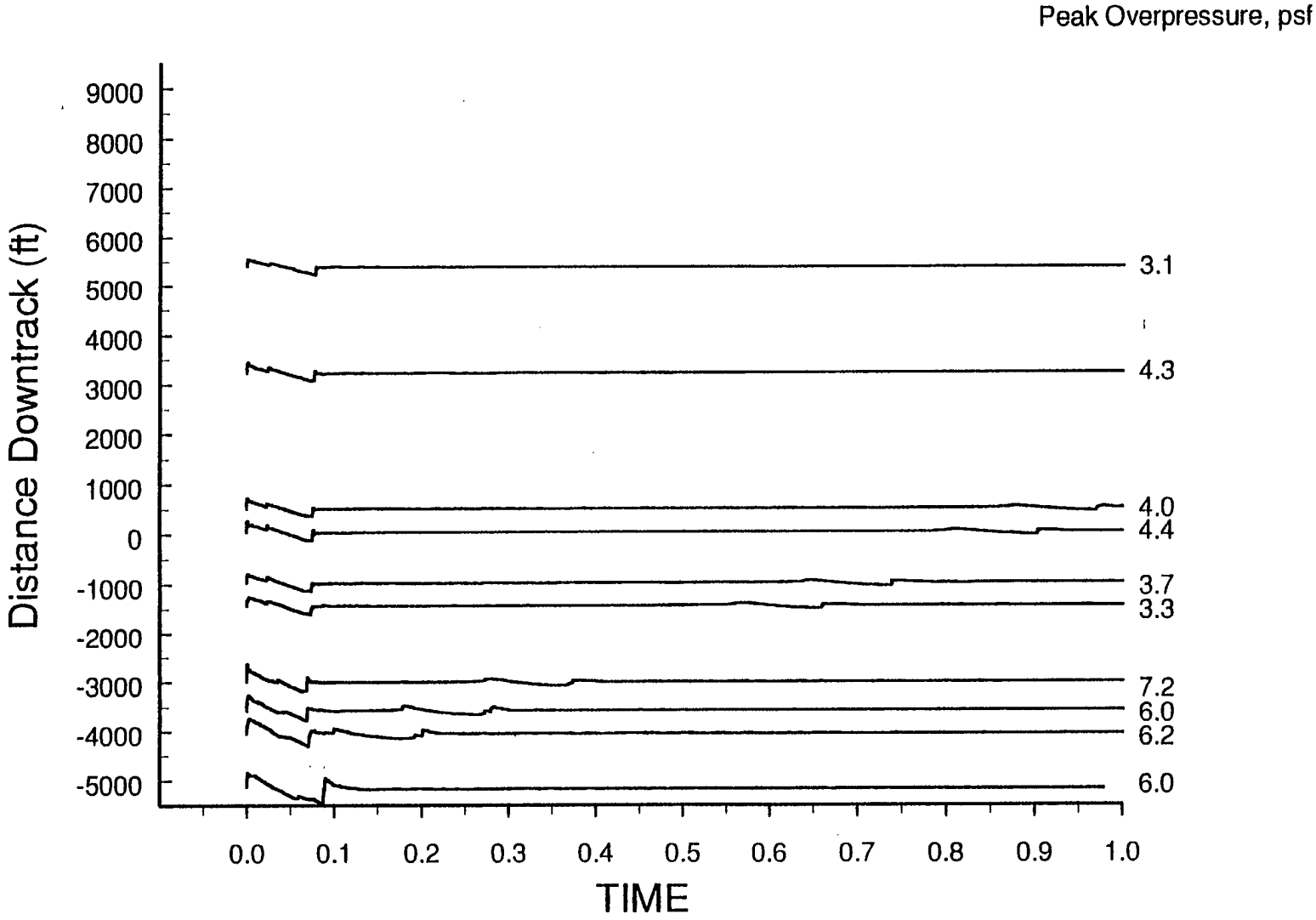

Figure C-5 Sonic boom signatures from pass 20, 30° diving acceleration

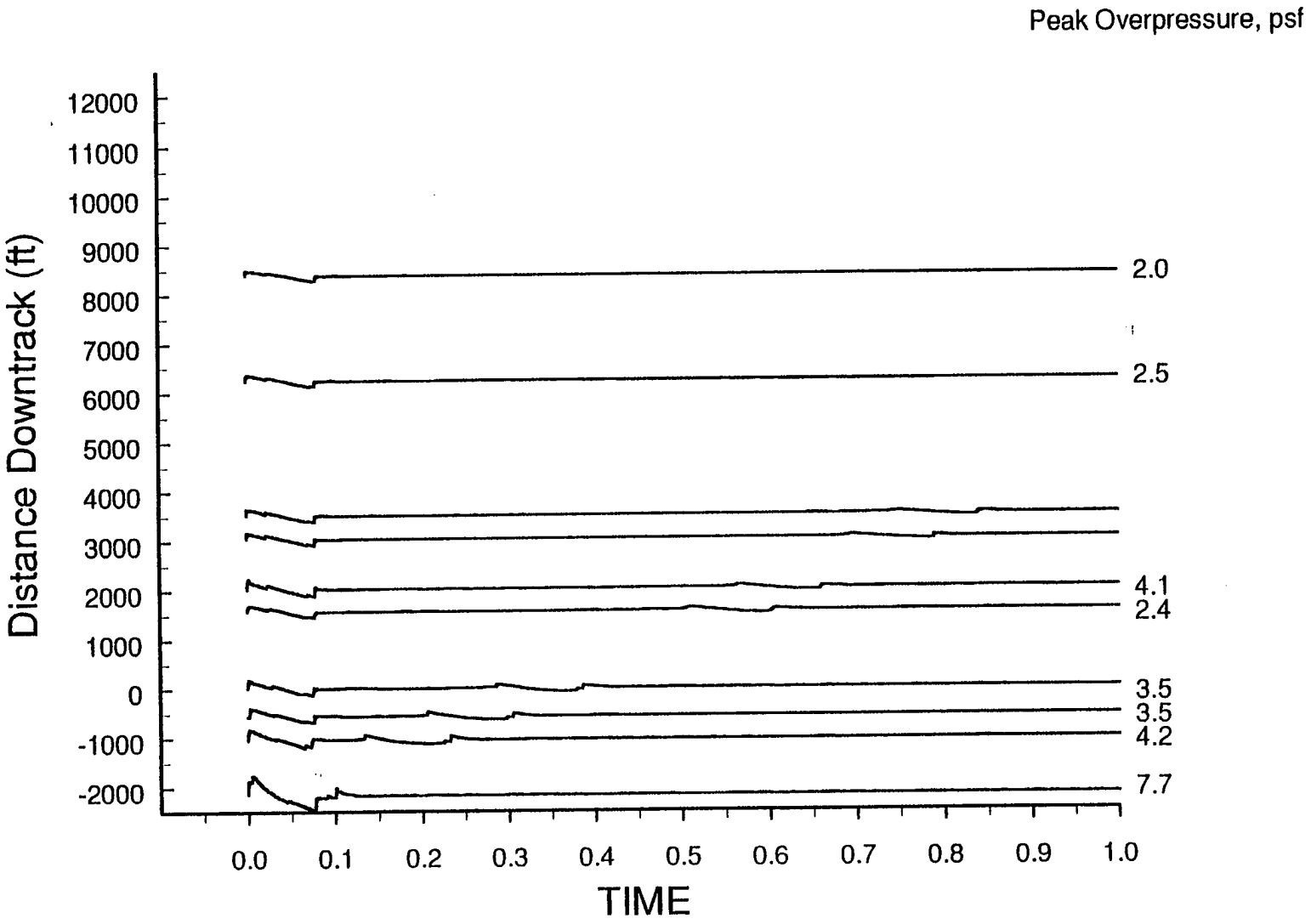

Figure C-6 Sonic boom signatures from pass 21, 30° diving acceleration

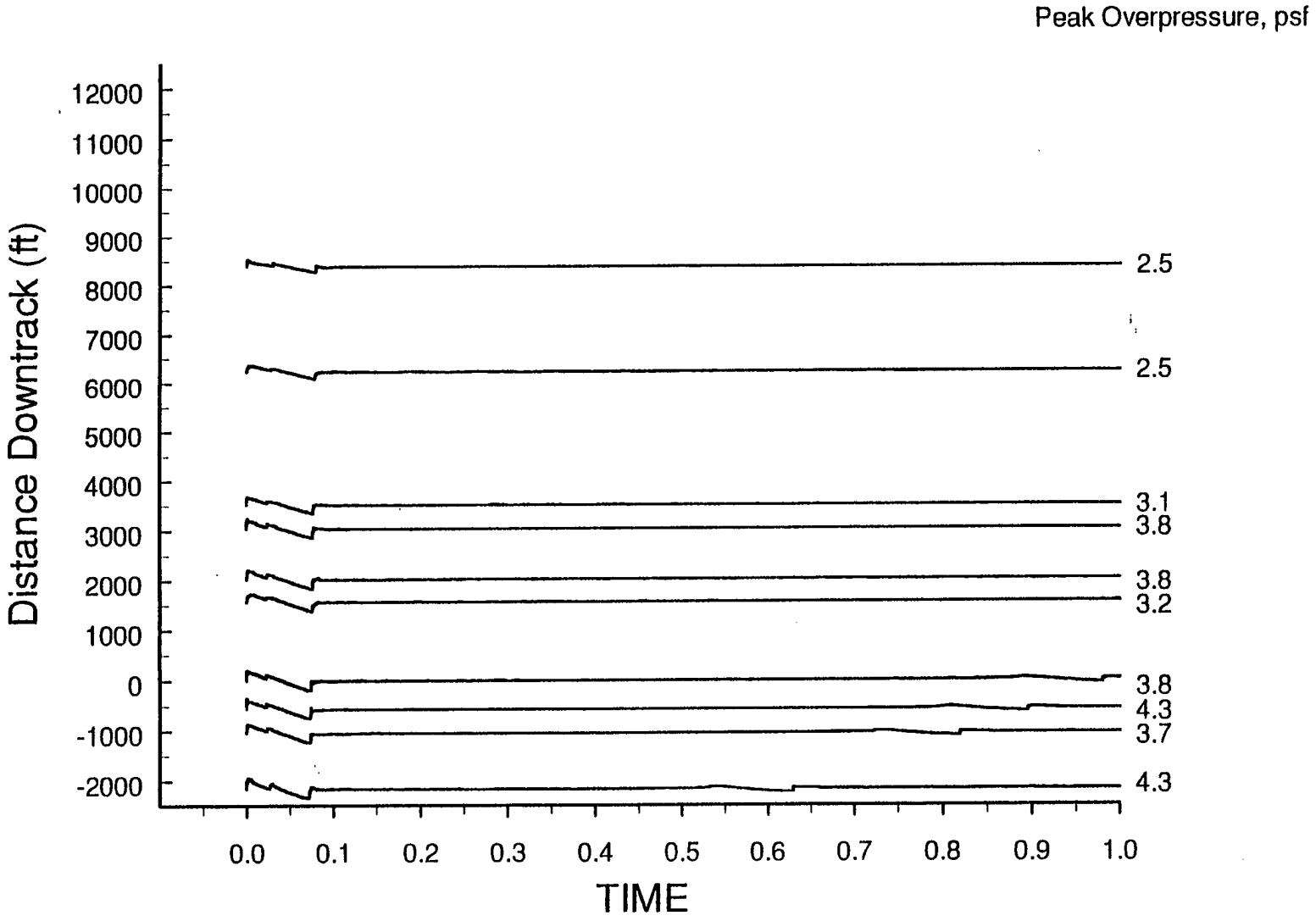

Figure C-7 Sonic boom signatures from pass 22, 30° diving acceleration

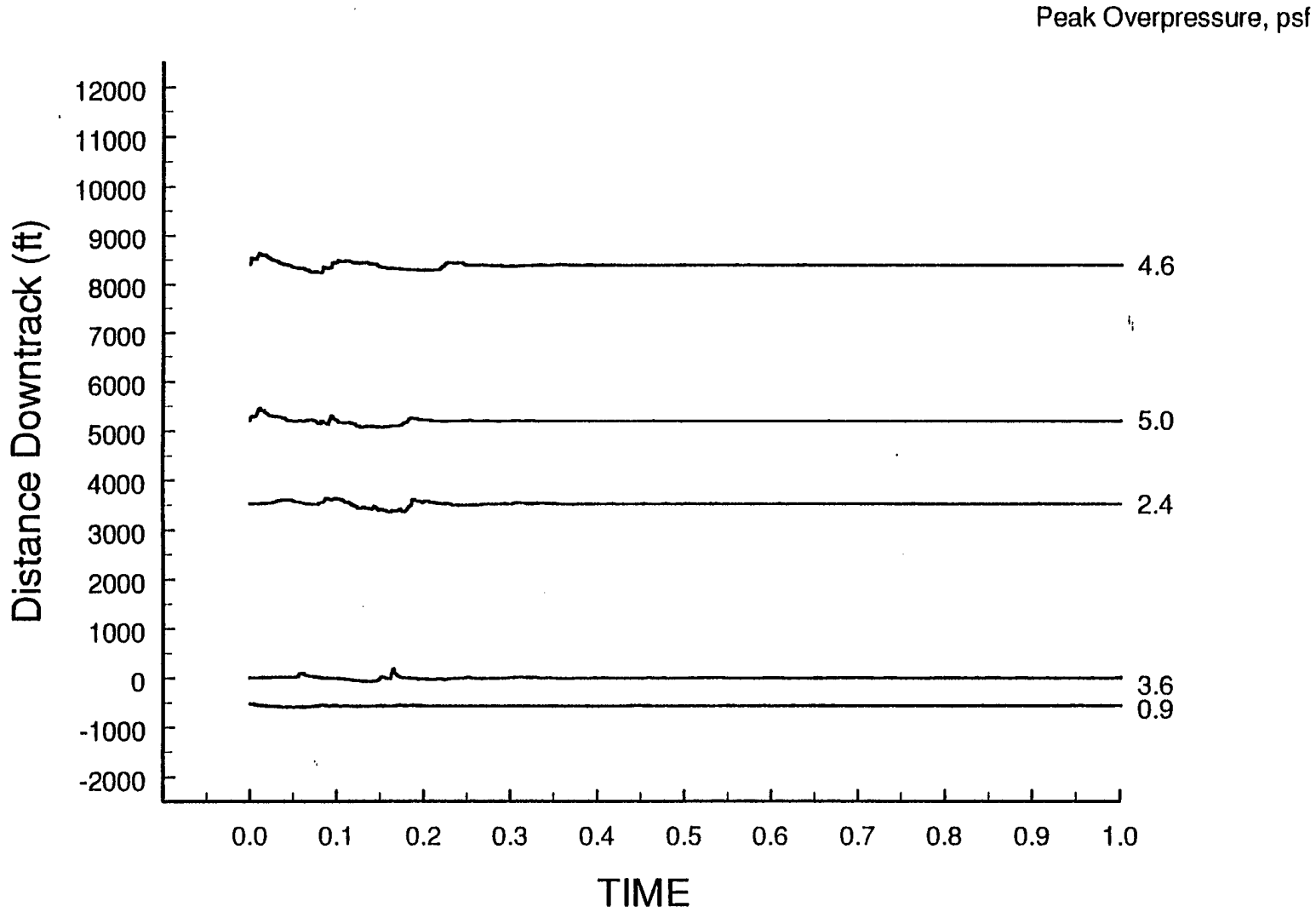

Figure C-8 Sonic boom signatures from pass 23, level acceleration

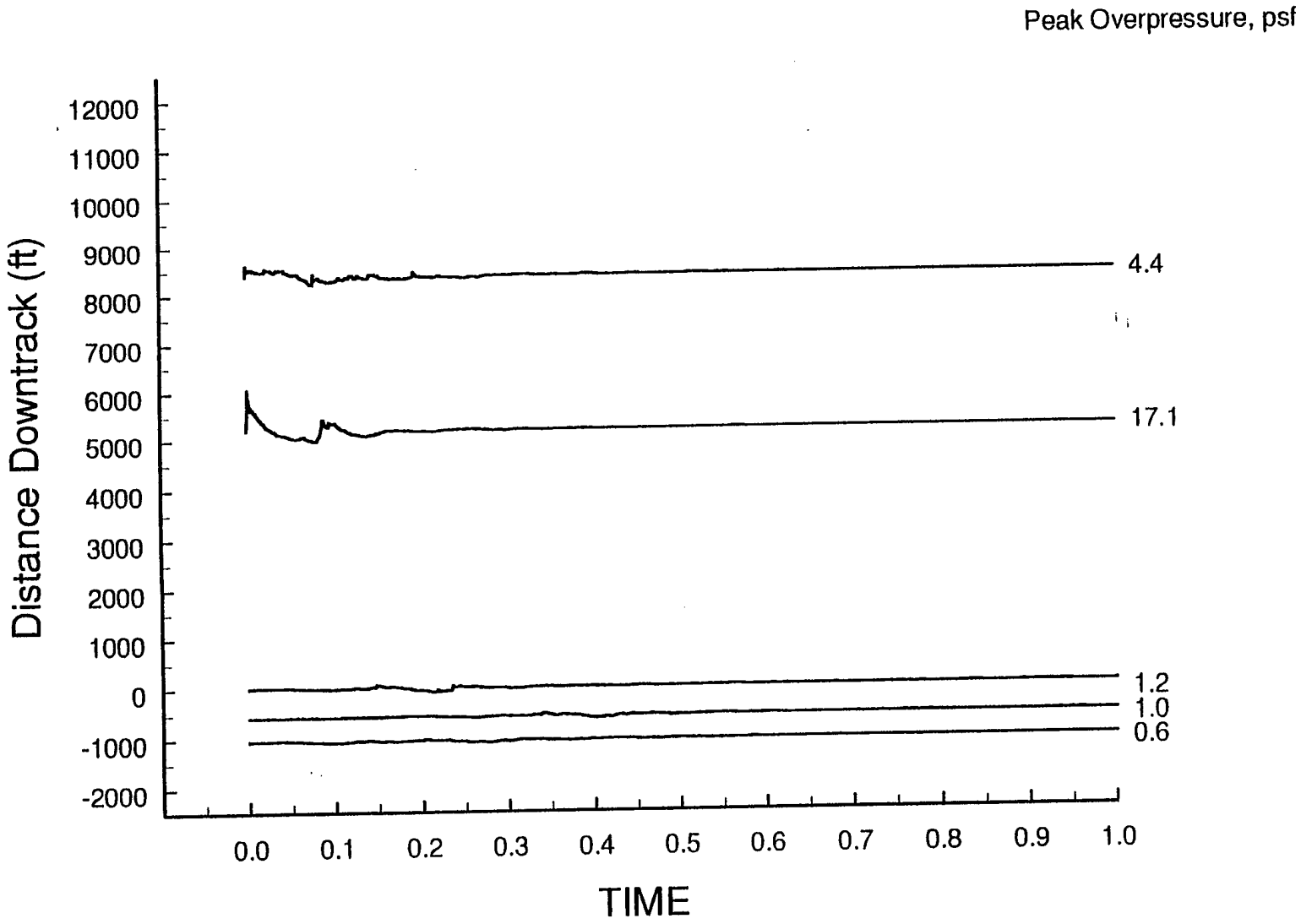

Figure C-9 Sonic boom signatures from pass 24, level acceleration

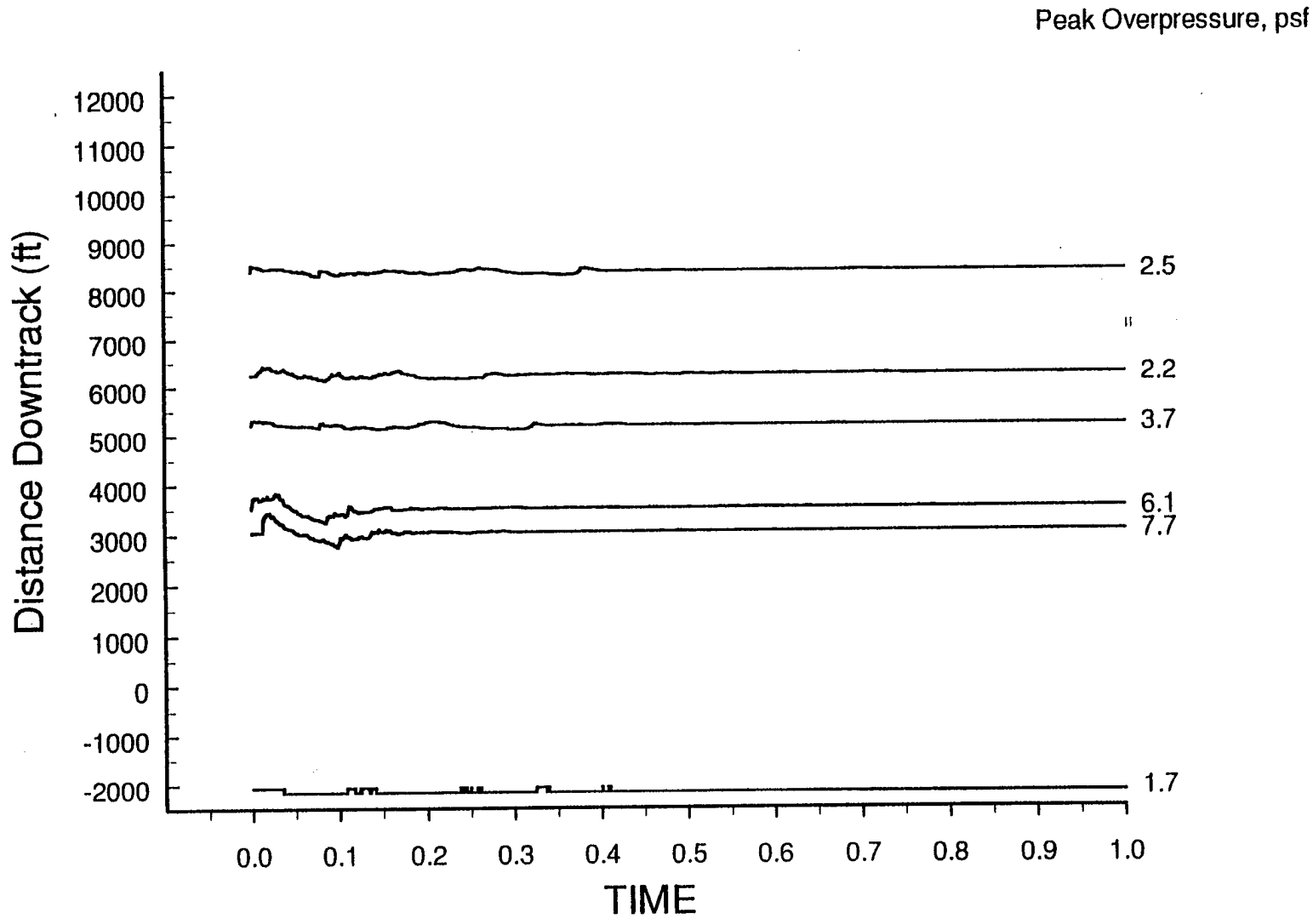

Figure C-10 Sonic boom signatures from pass 25, level acceleration

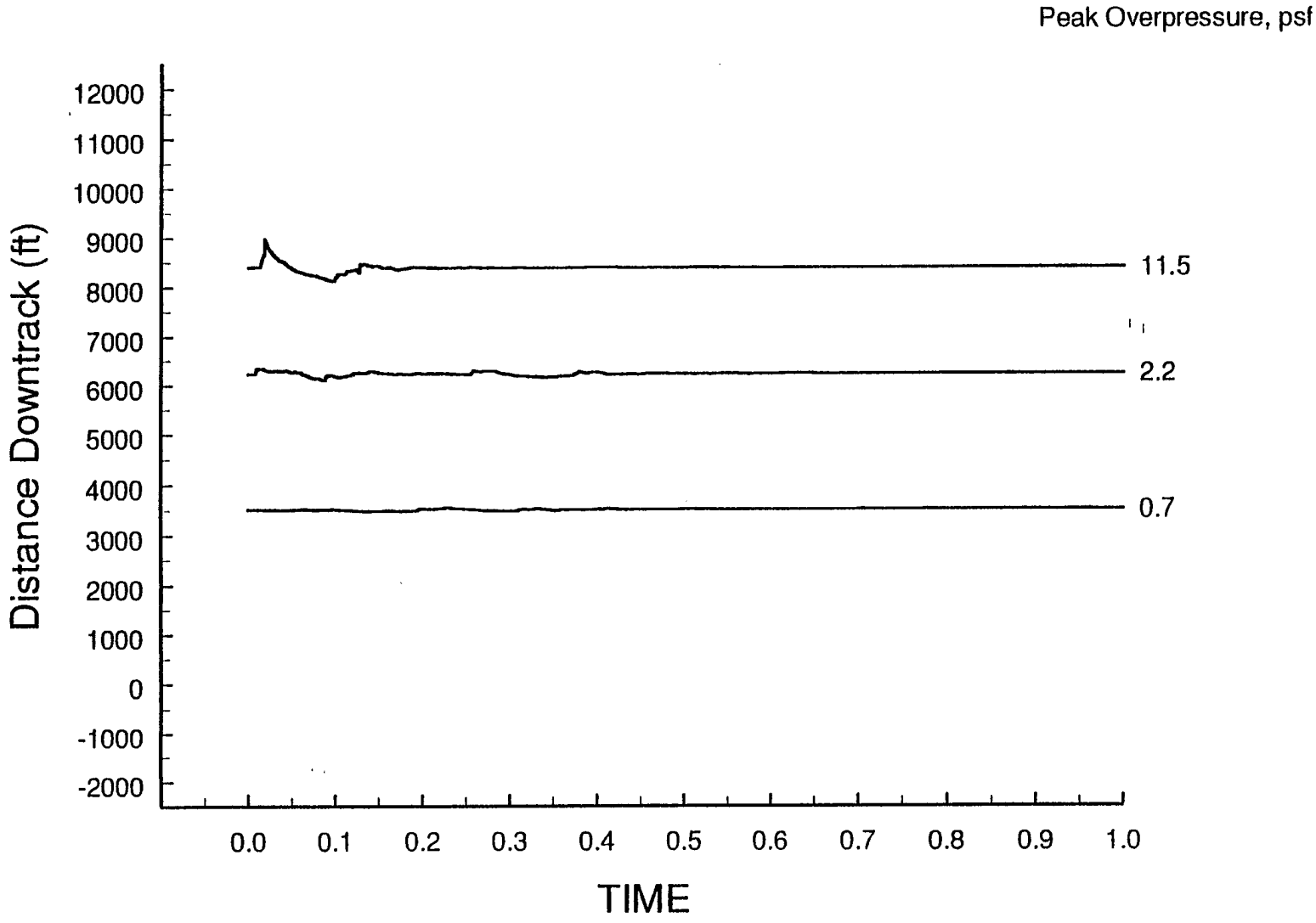

Figure C-11 Sonic boom signatures from pass 26, level acceleration

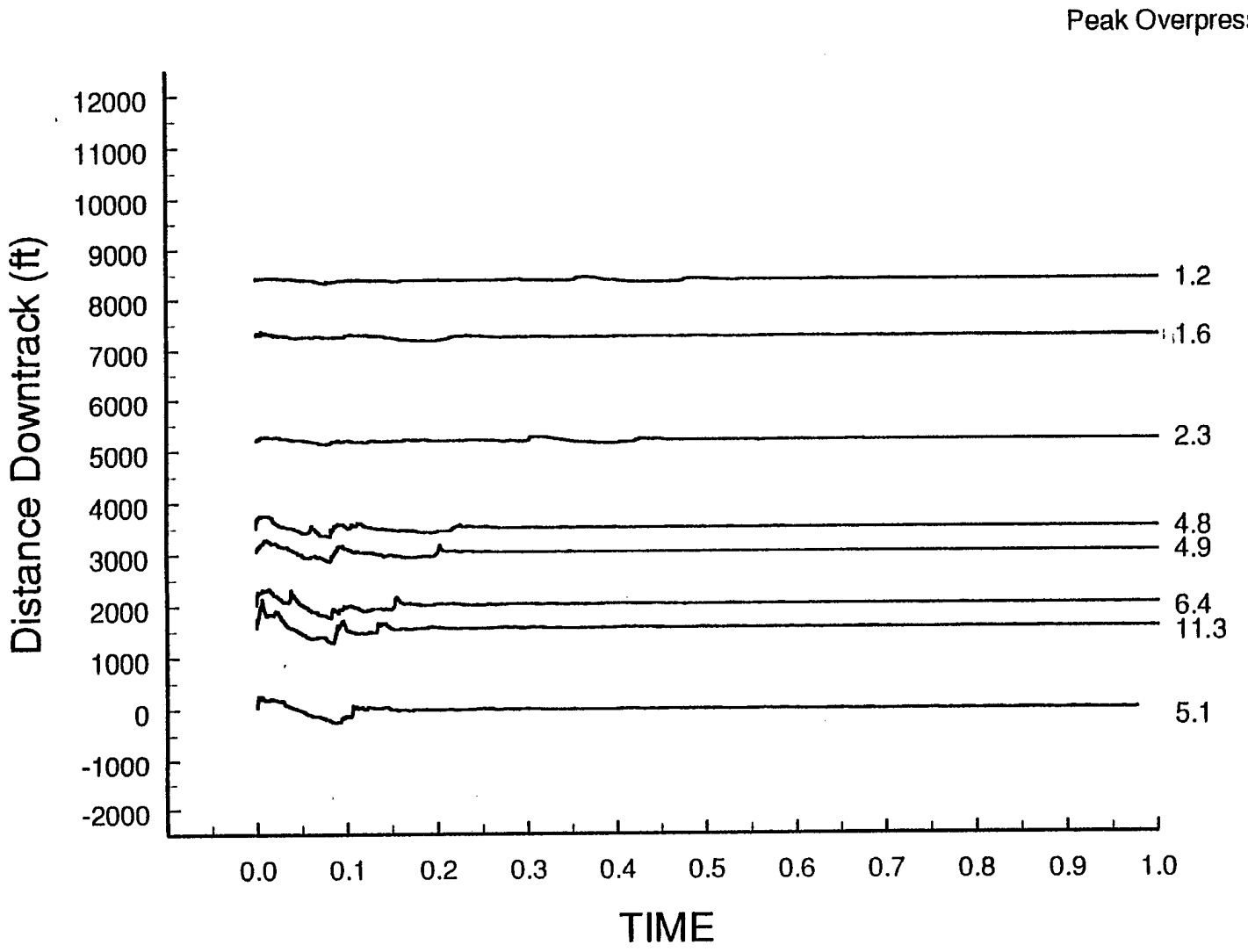

Figure C-12 Sonic boom signatures from pass 27, level acceleration

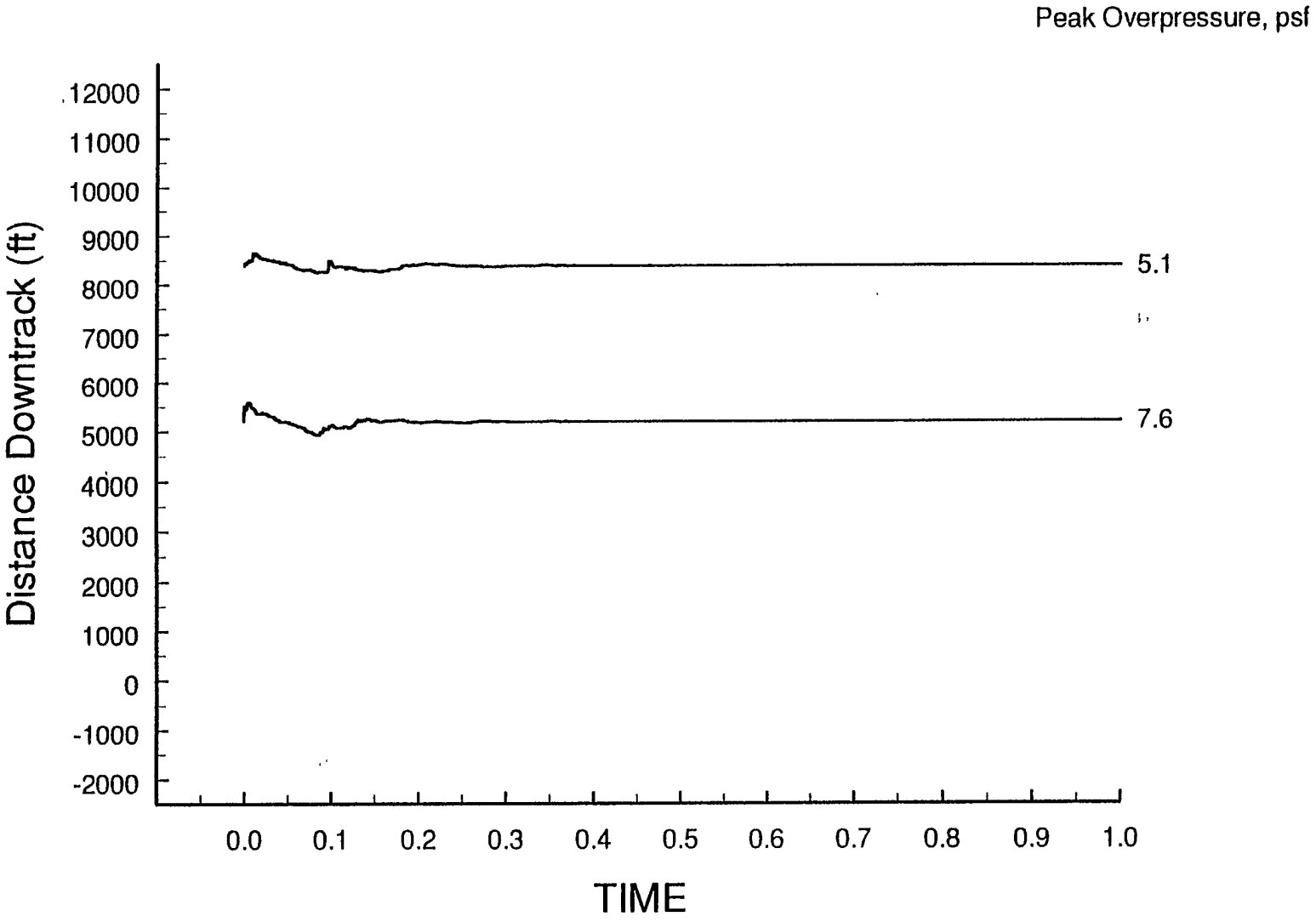

Figure C-13 Sonic boom signatures from pass 28, level acceleration

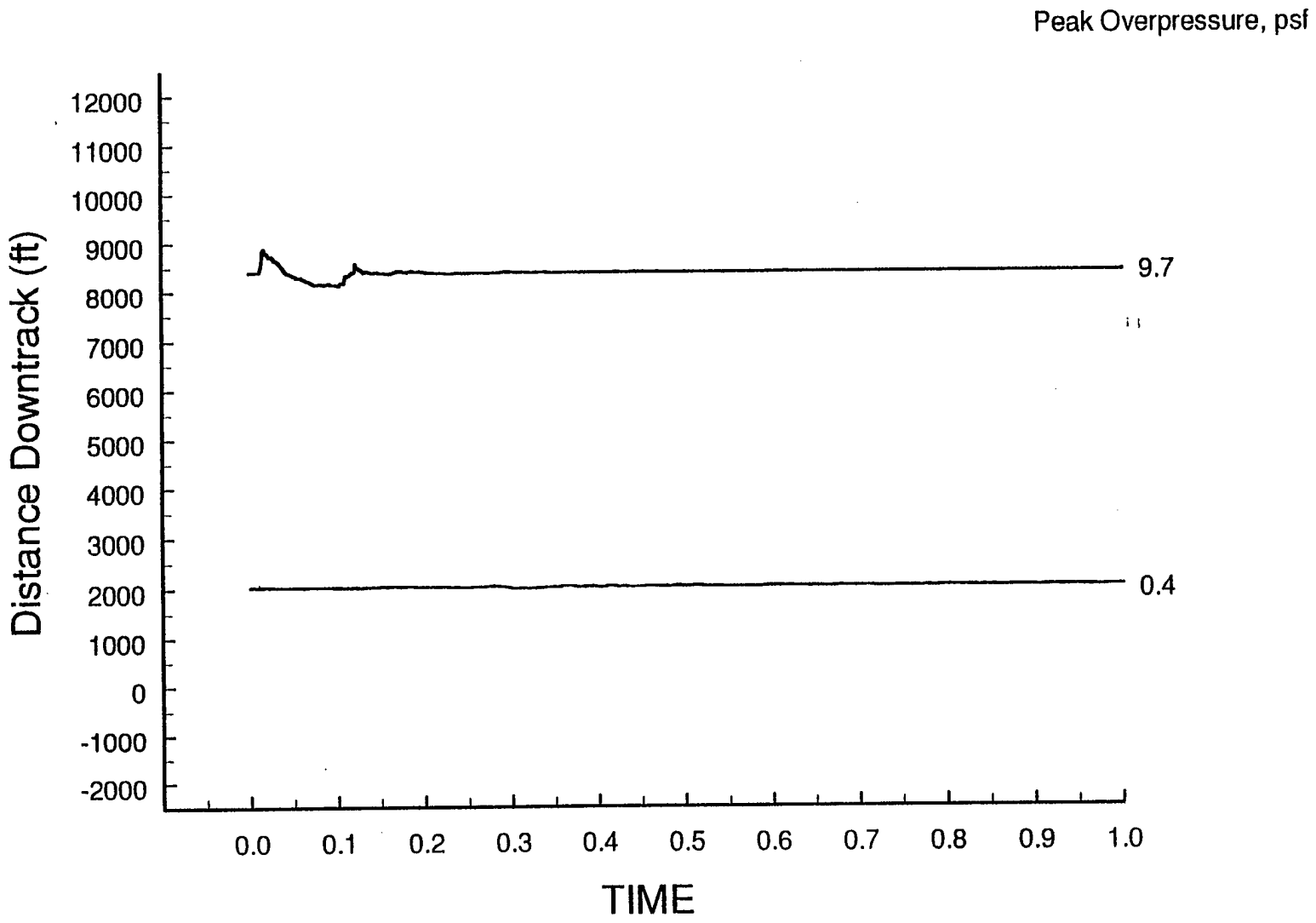

Figure C-14 Sonic boom signatures from pass 29, level acceleration

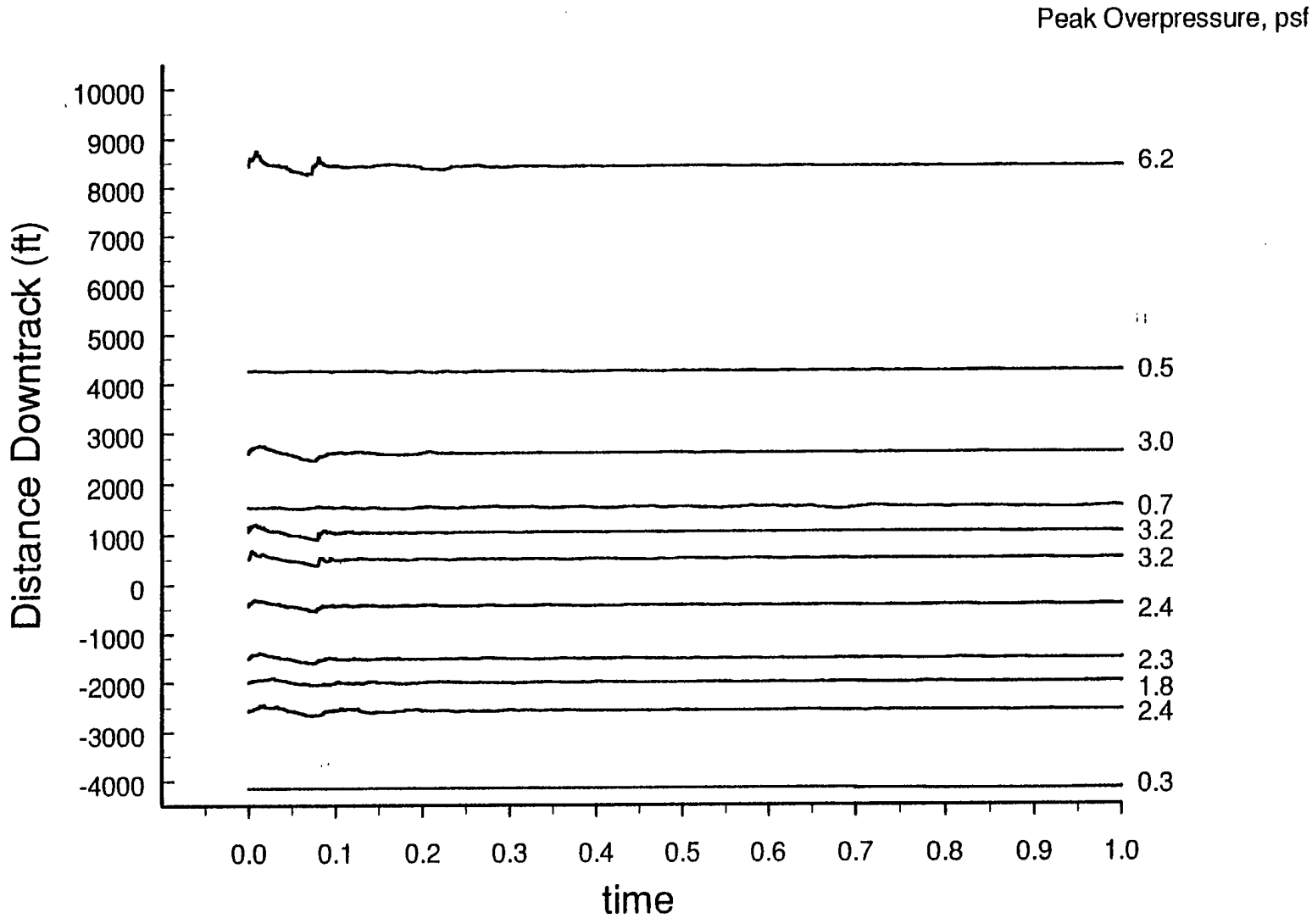

Figure C-15 Sonic boom signatures from pass 30, level 4g turn

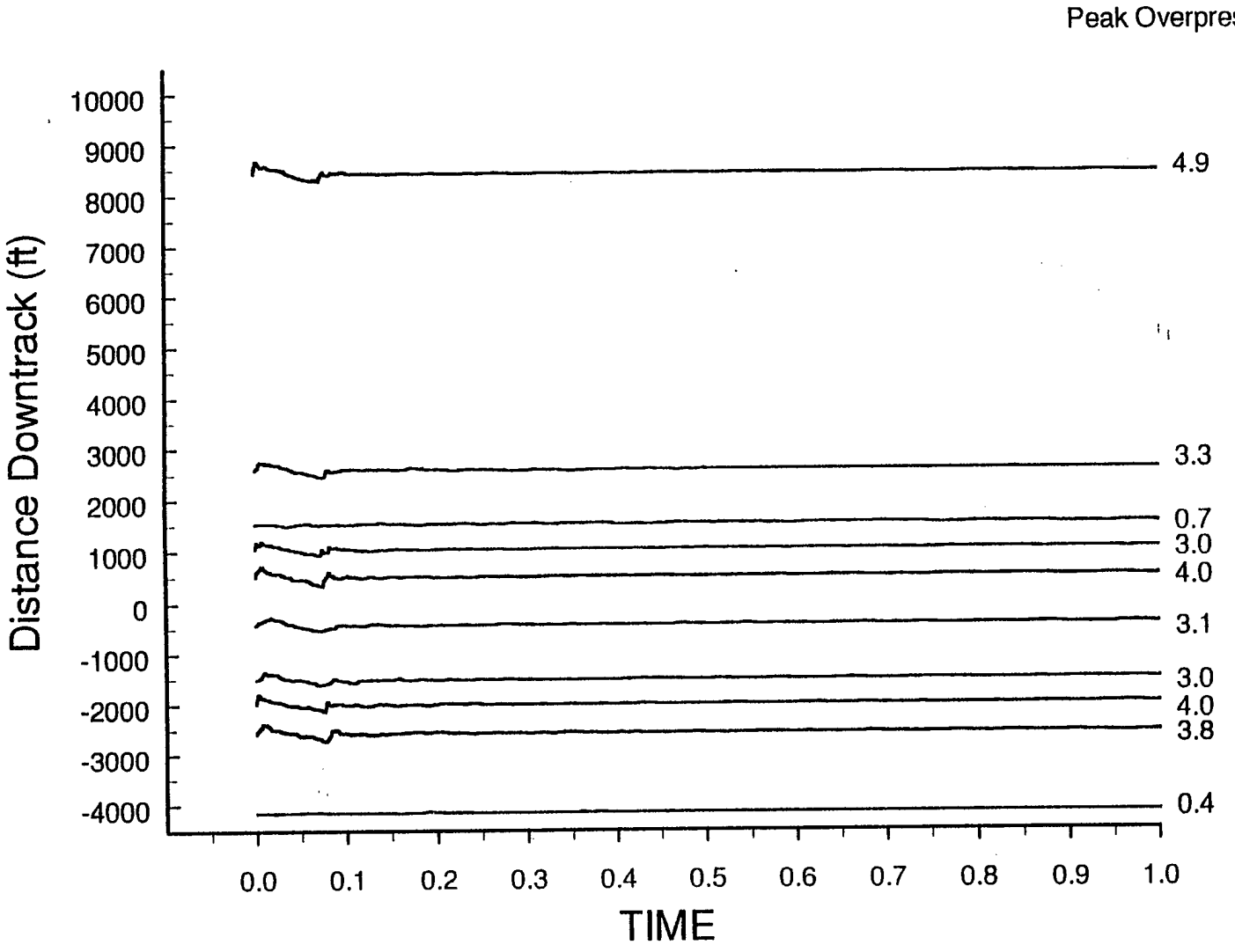

Figure C-16 Sonic boom signatures from pass 31, level 4g turn

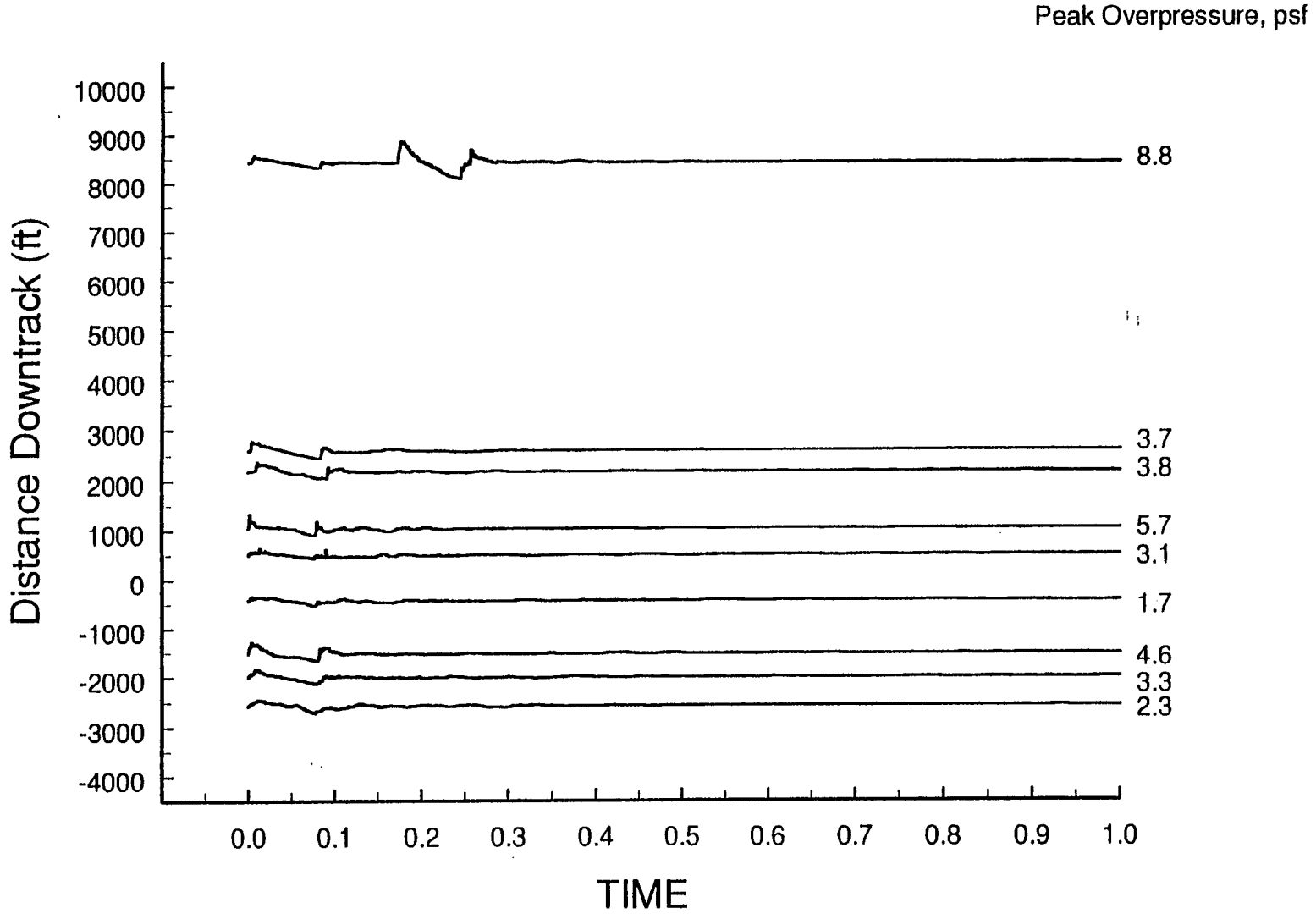

Figure C-17 Sonic boom signatures from pass 32, level 4g turn

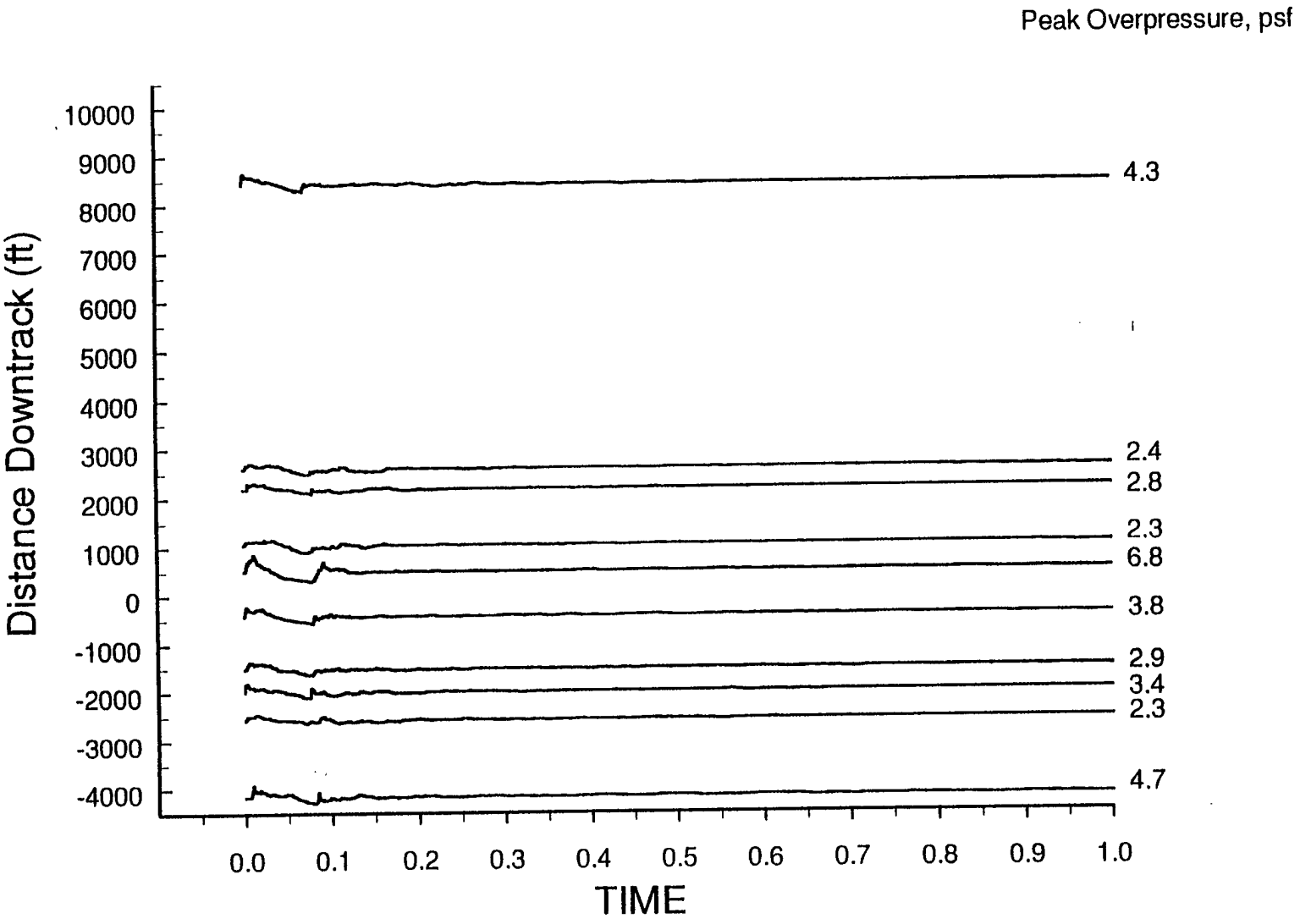

Figure C-18 Sonic boom signatures from pass 33, level 4g turn

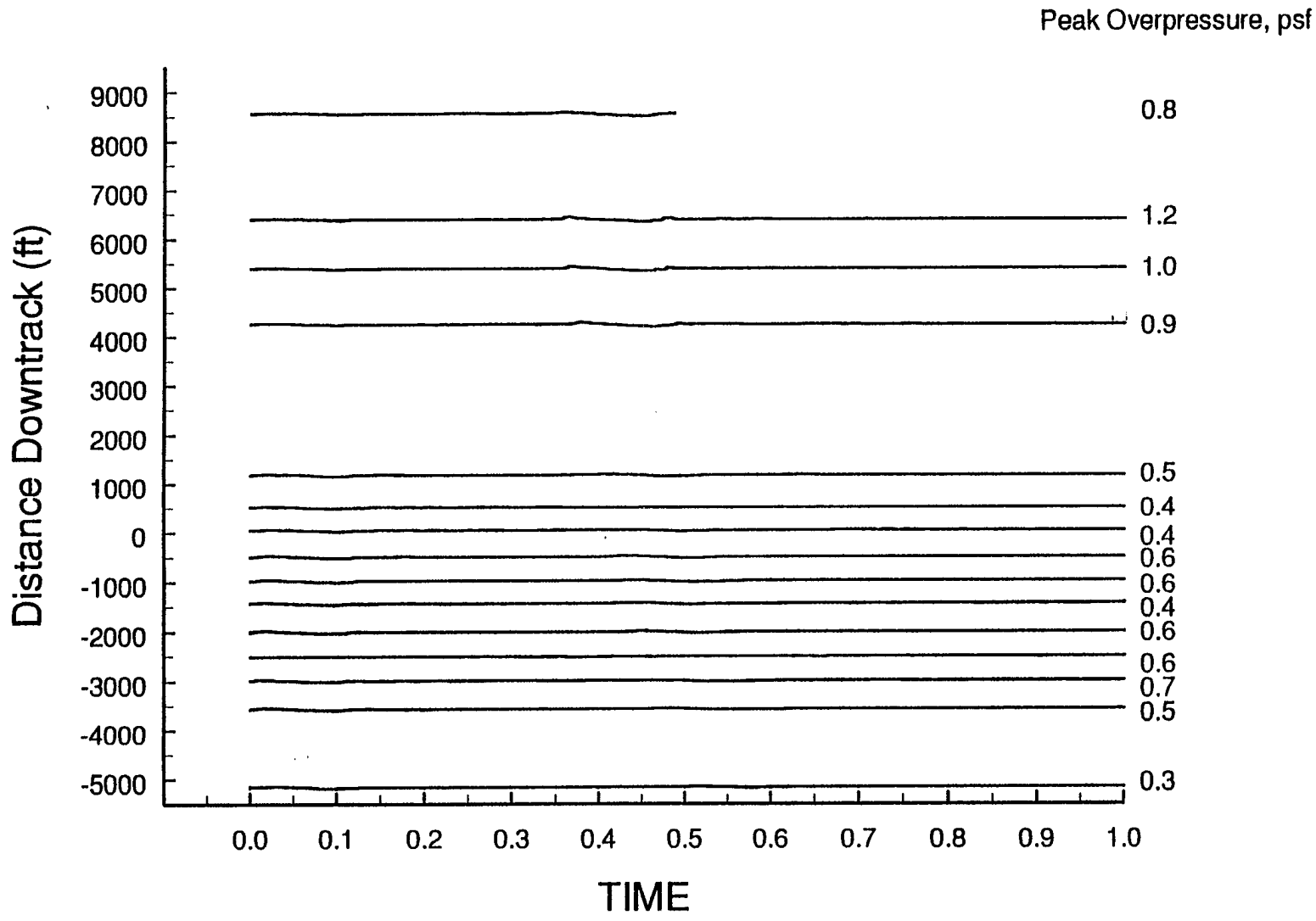

Figure C-19 Sonic boom signatures from pass 34, level 4g turn

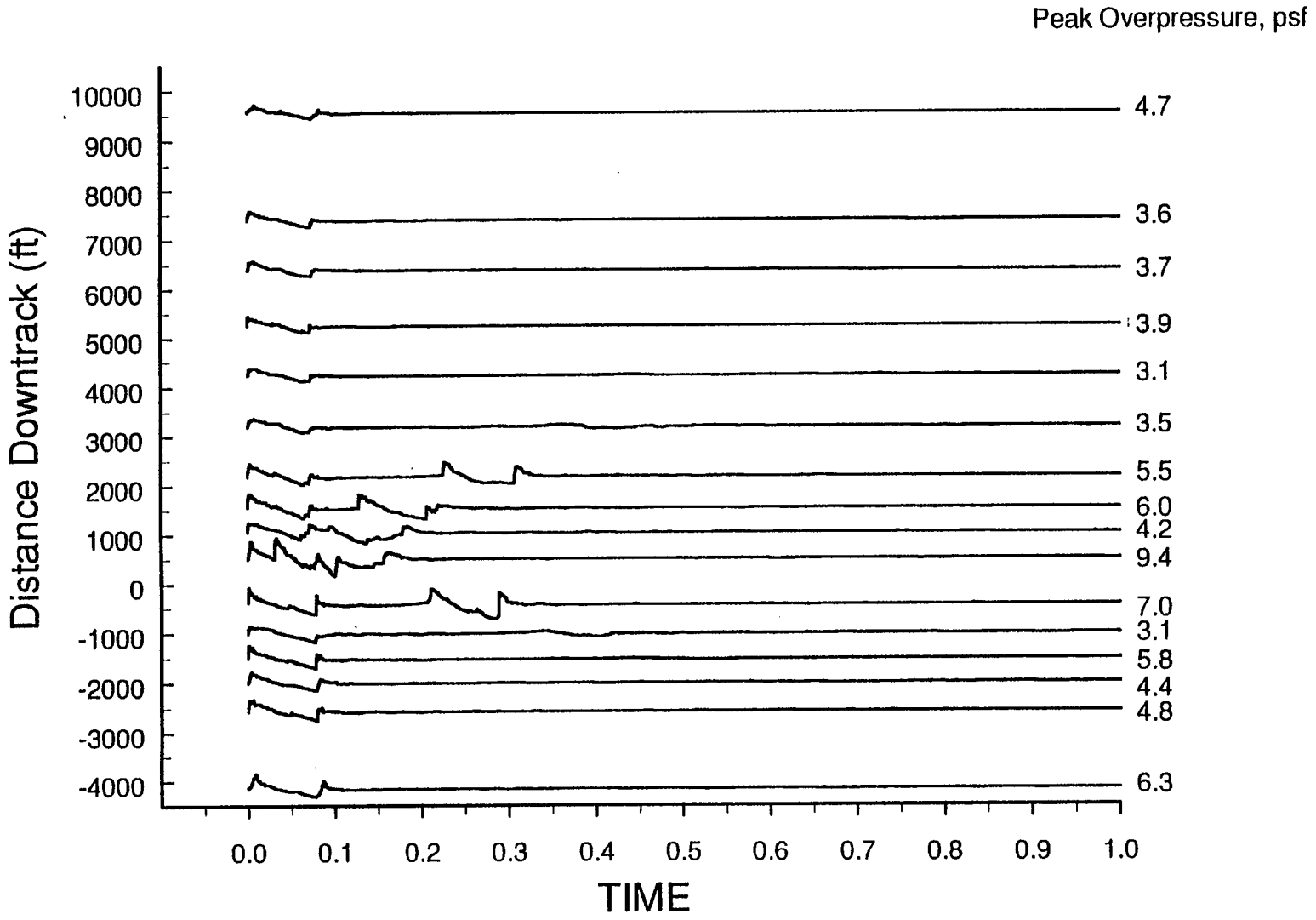

Figure C-20 Sonic boom signatures from pass 35, level 4g turn

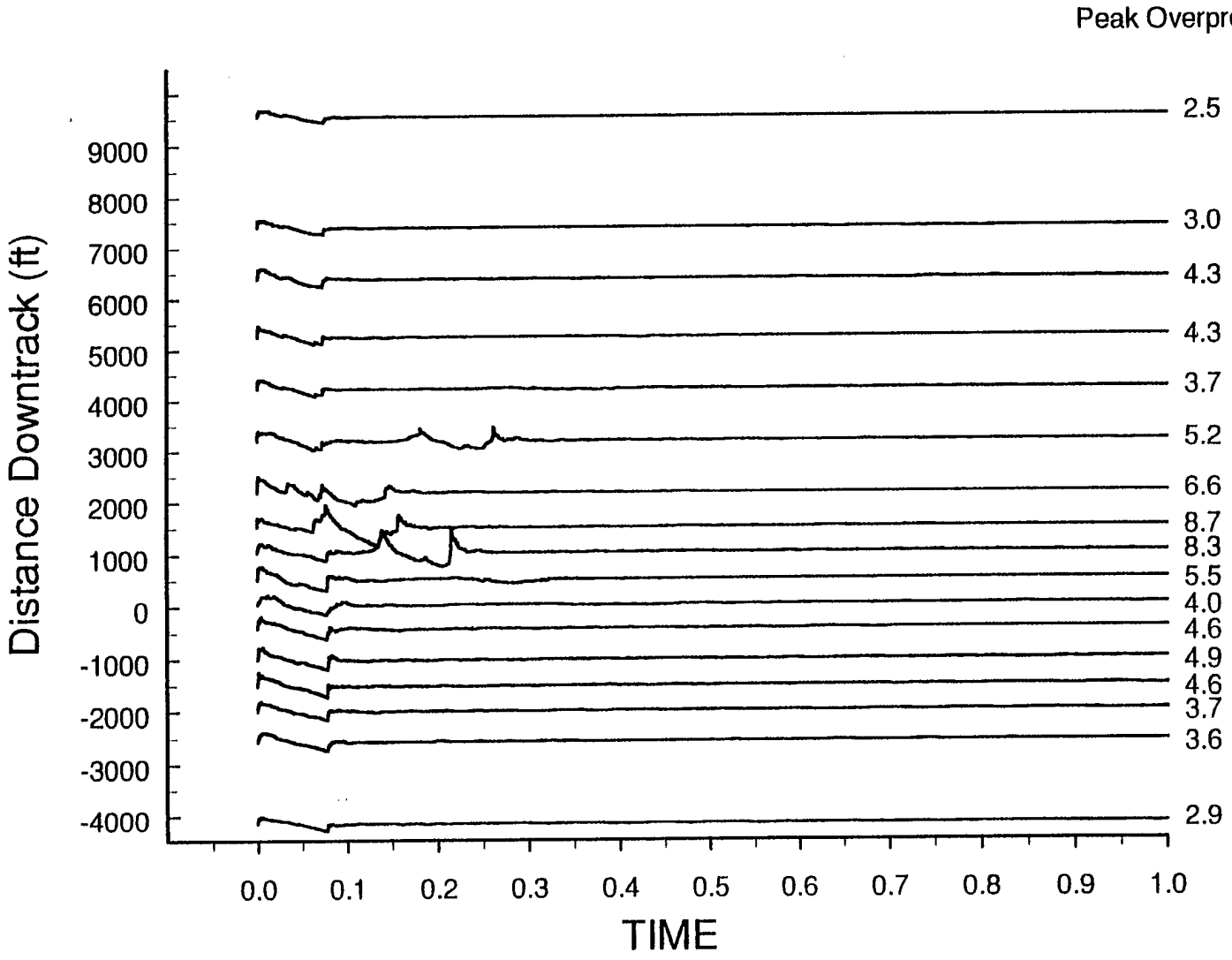

Figure C-21 Sonic boom signatures from pass 36, level 4g turn

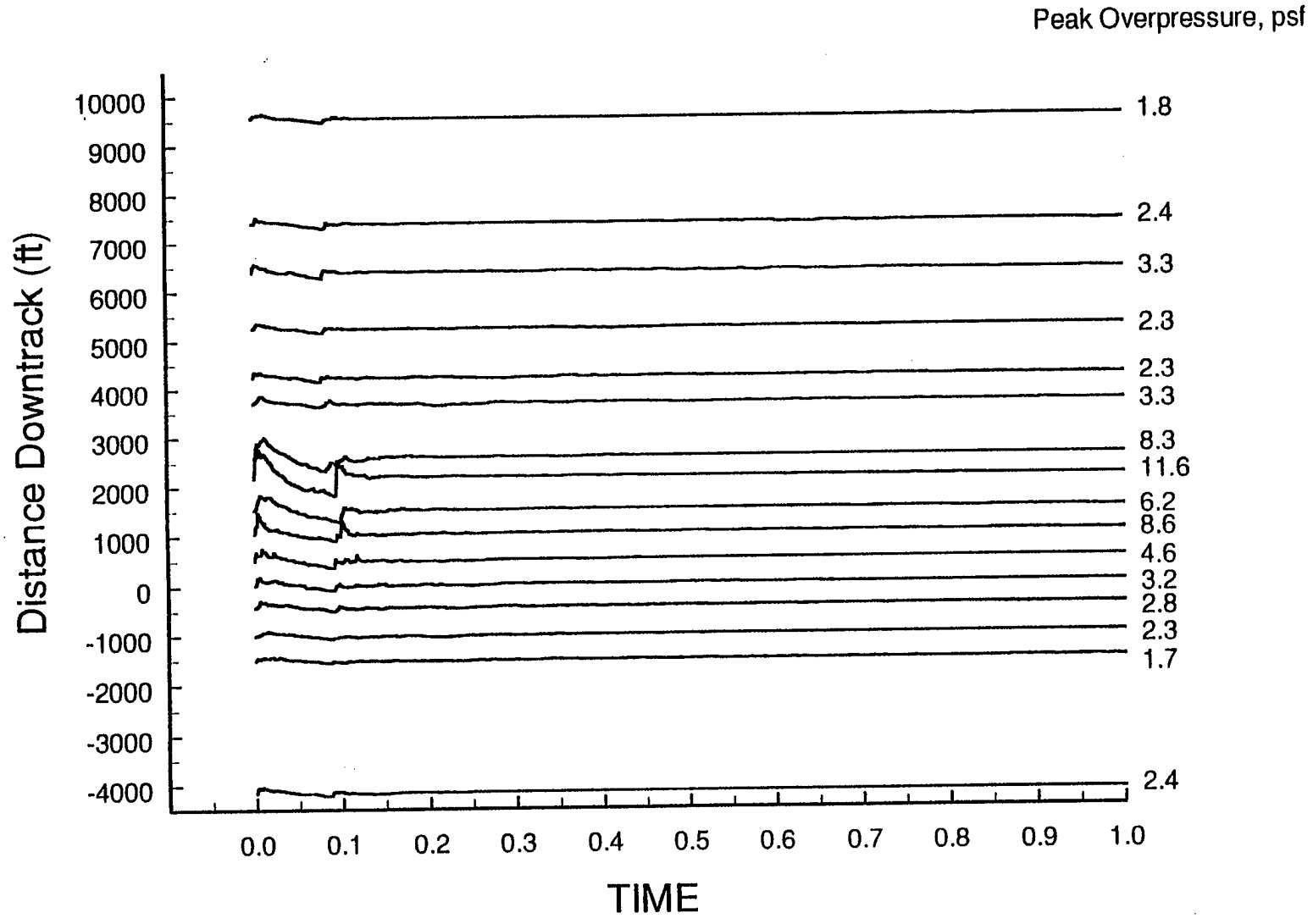

Figure C-22 Sonic boom signatures from pass 37, climbout/pushover

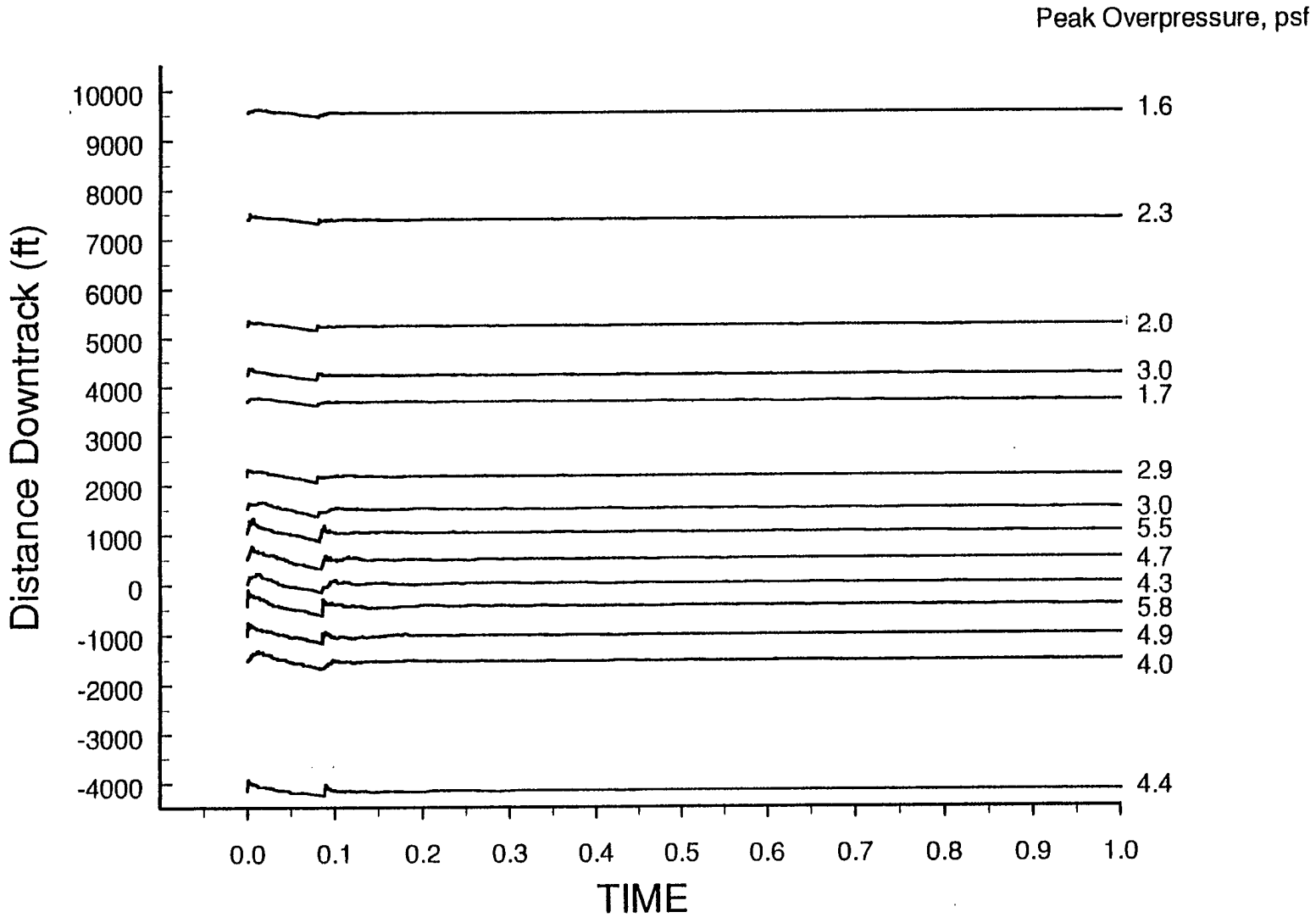

Figure C-23 Sonic boom signatures from pass 38, climbout/pushover

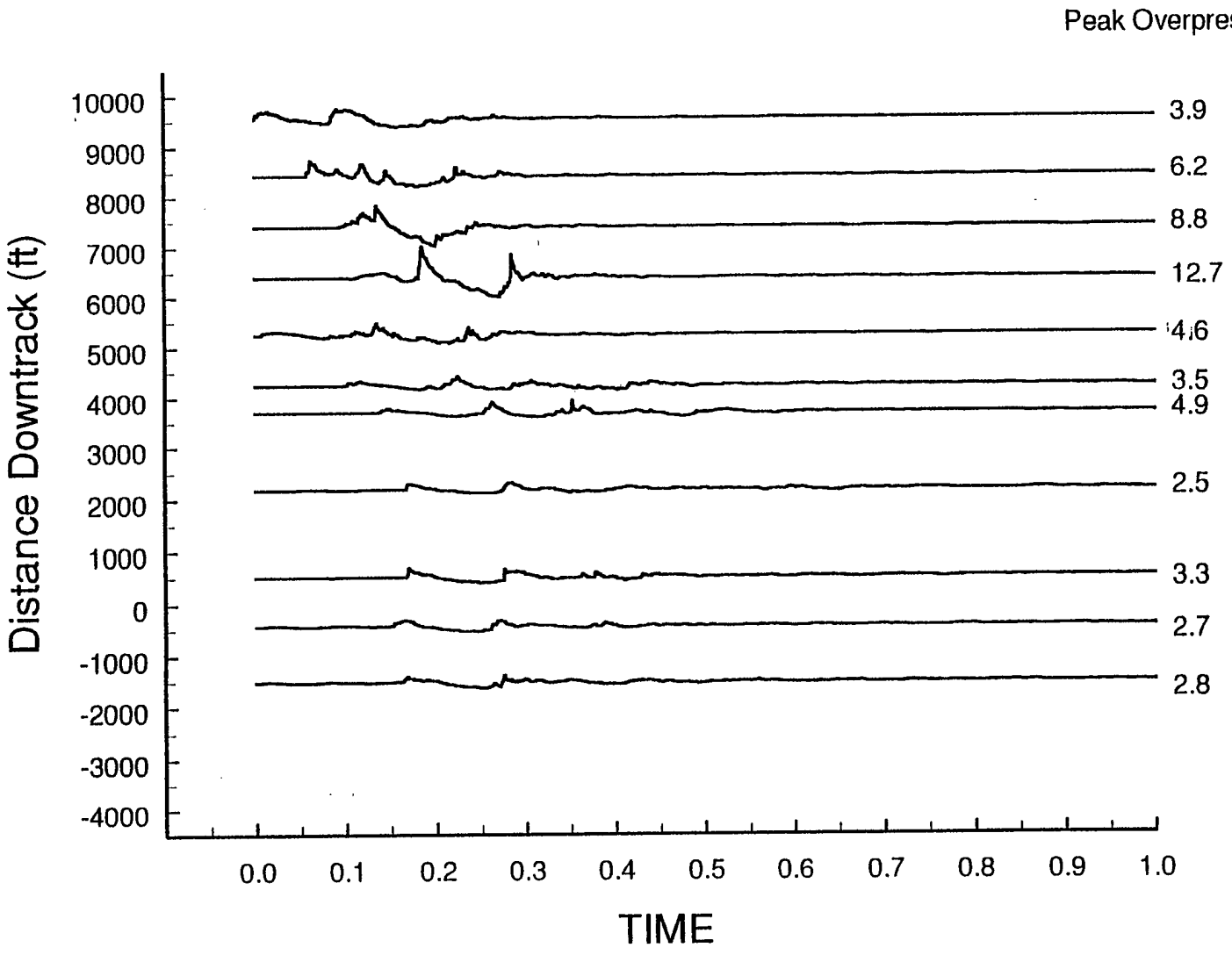

Figure C-24 Sonic boom signatures from pass 39, level acceleration (autonomous)

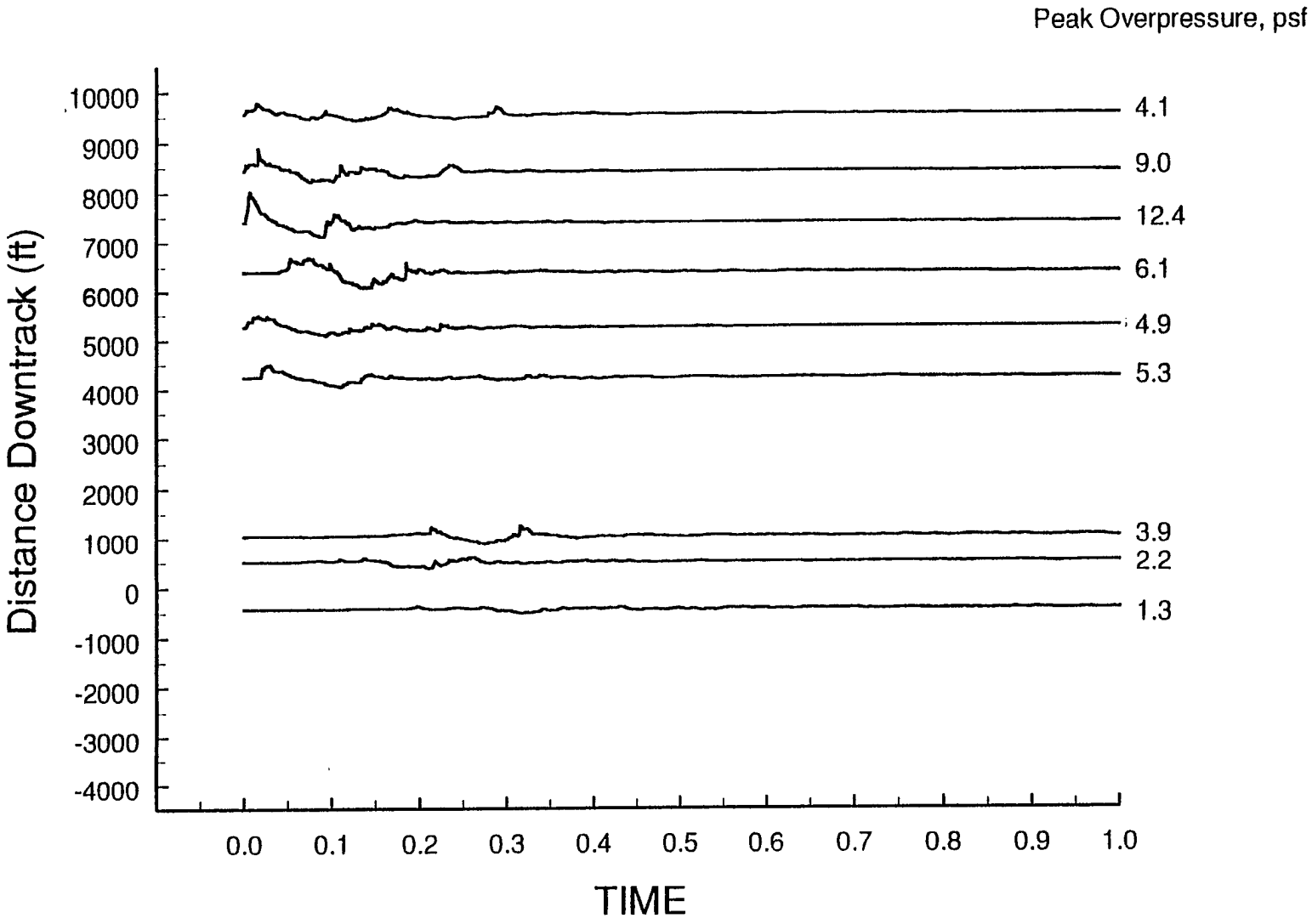

Figure C-25 Sonic boom signatures from pass 40, level acceleration (autonomous)

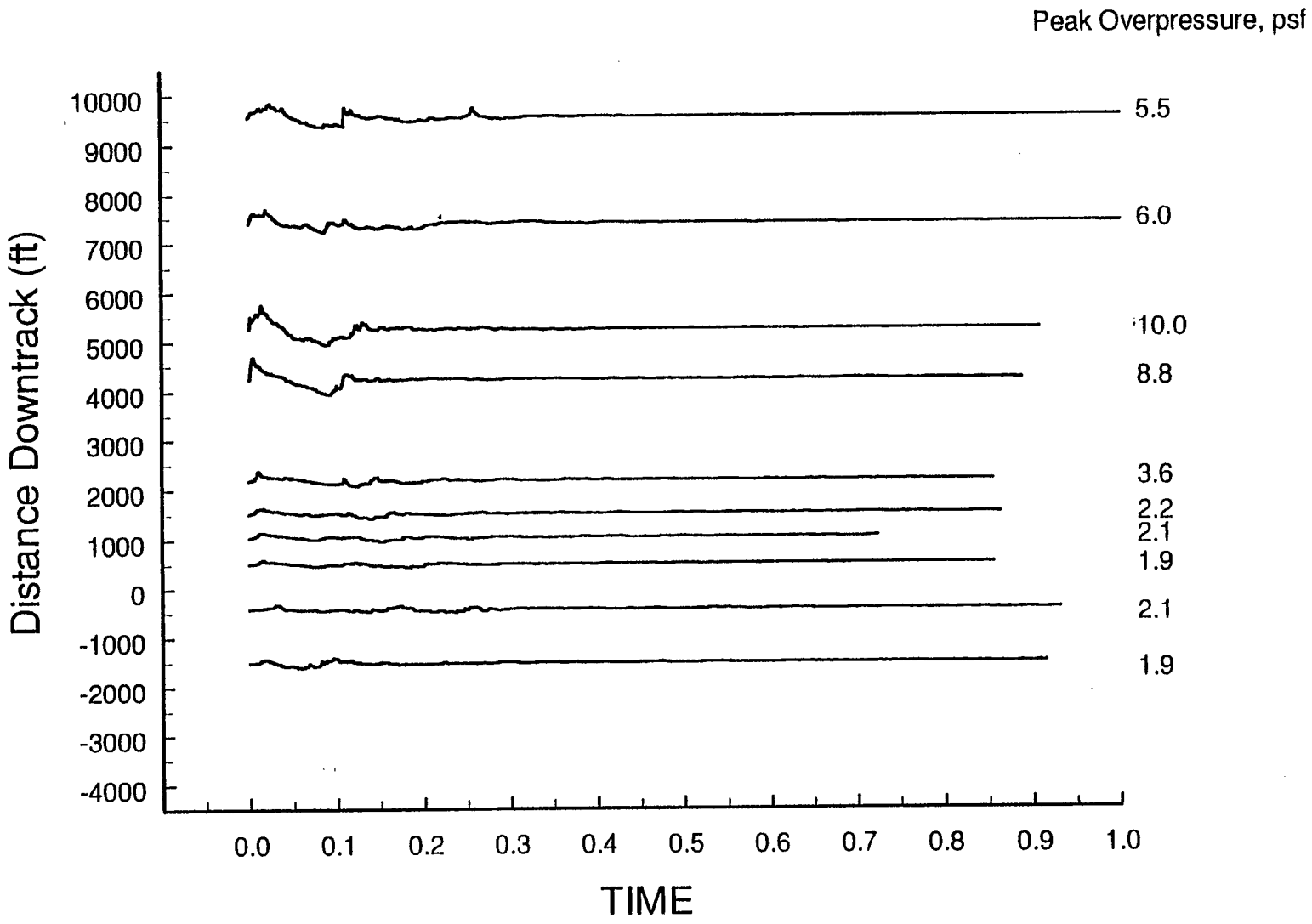

Figure C-26 Sonic boom signatures from pass 41, level acceleration (autonomous)

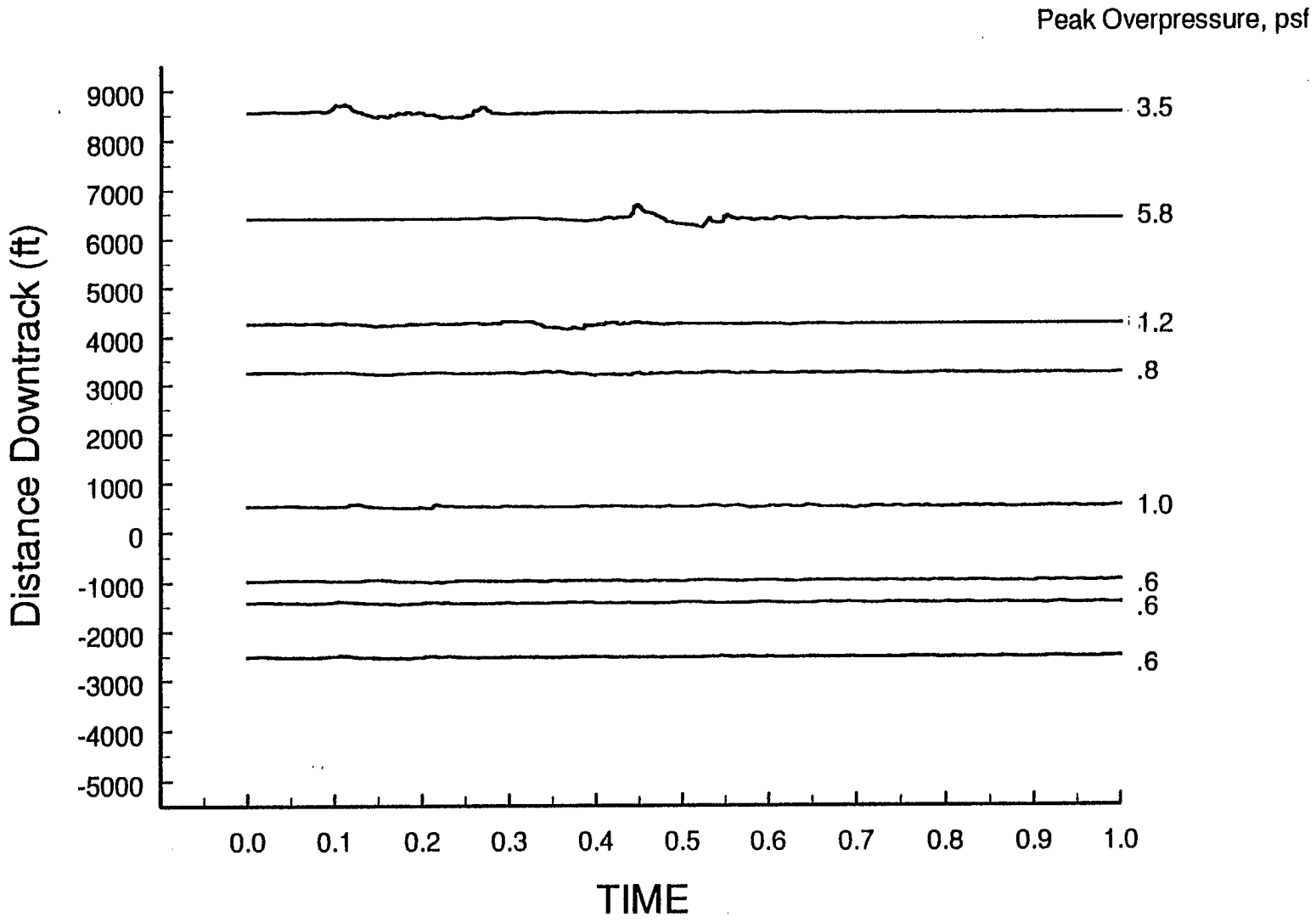

Figure C-27 Sonic boom signatures from pass 42, level acceleration (autonomous)

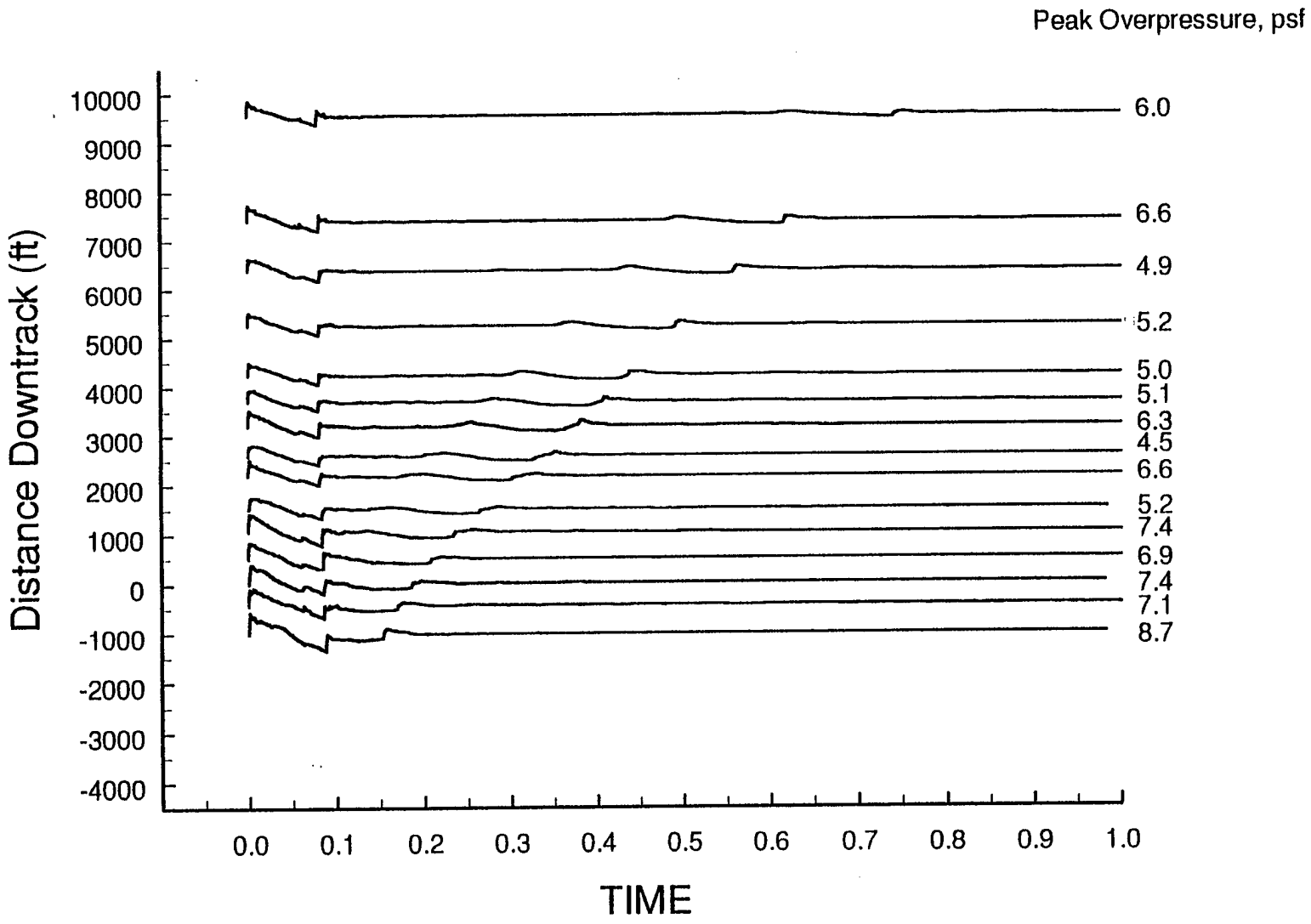

Figure C-28 Sonic boom signatures from pass 43, level acceleration (autonomous)

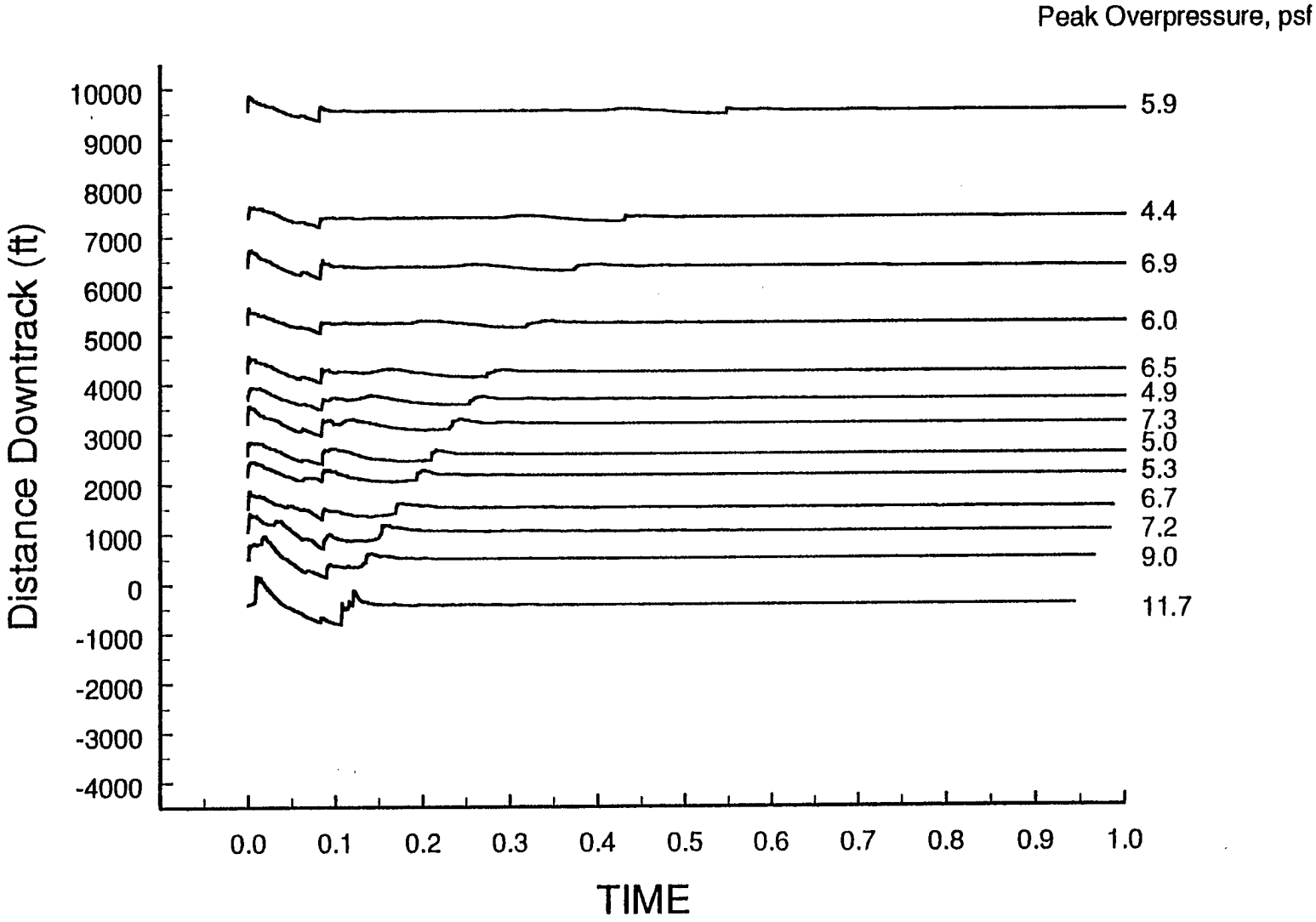

Figure C-29 Sonic boom signatures from pass 44, level acceleration (autonomous)

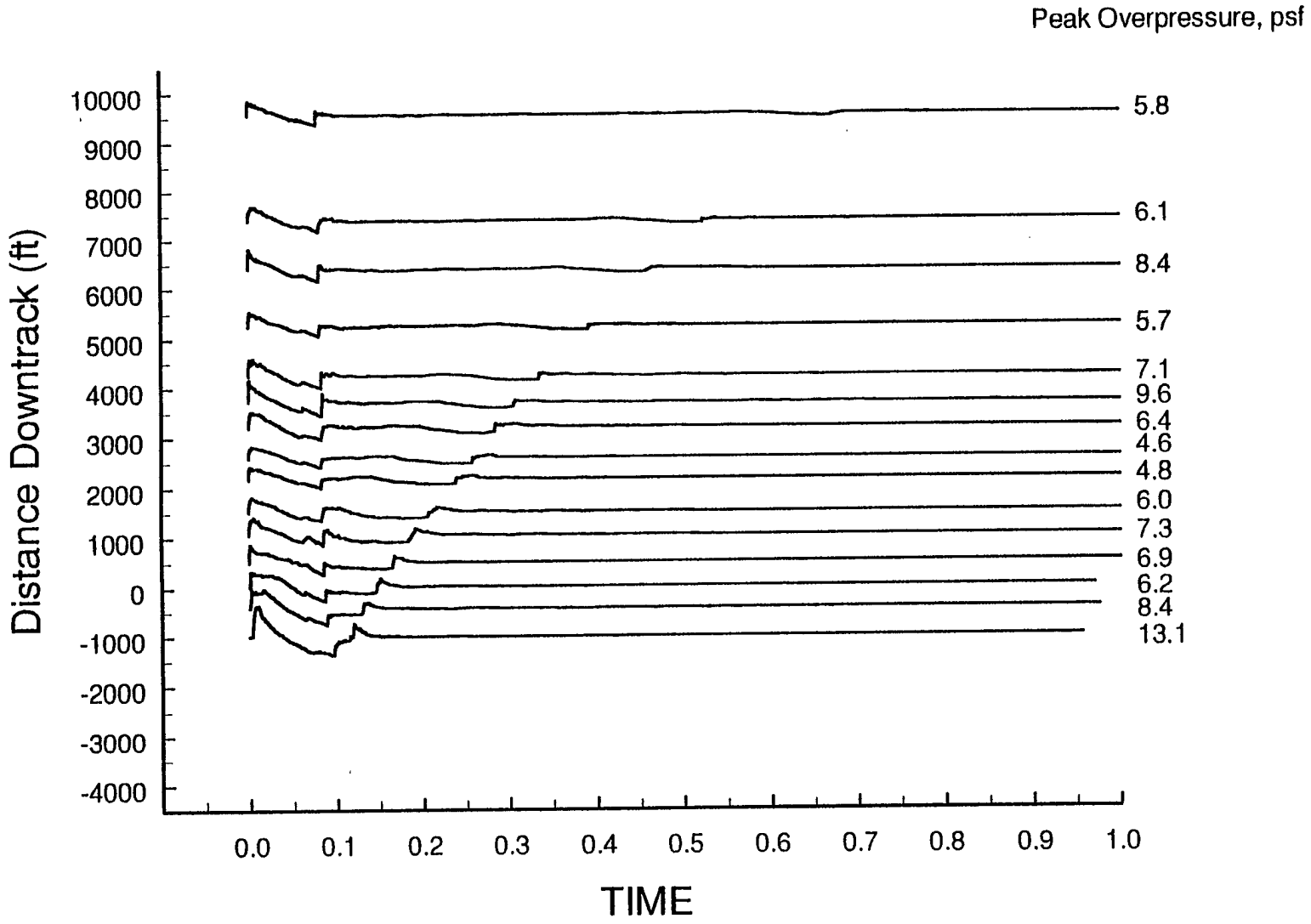

Figure C-30 Sonic boom signatures from pass 45, level acceleration (autonomous)

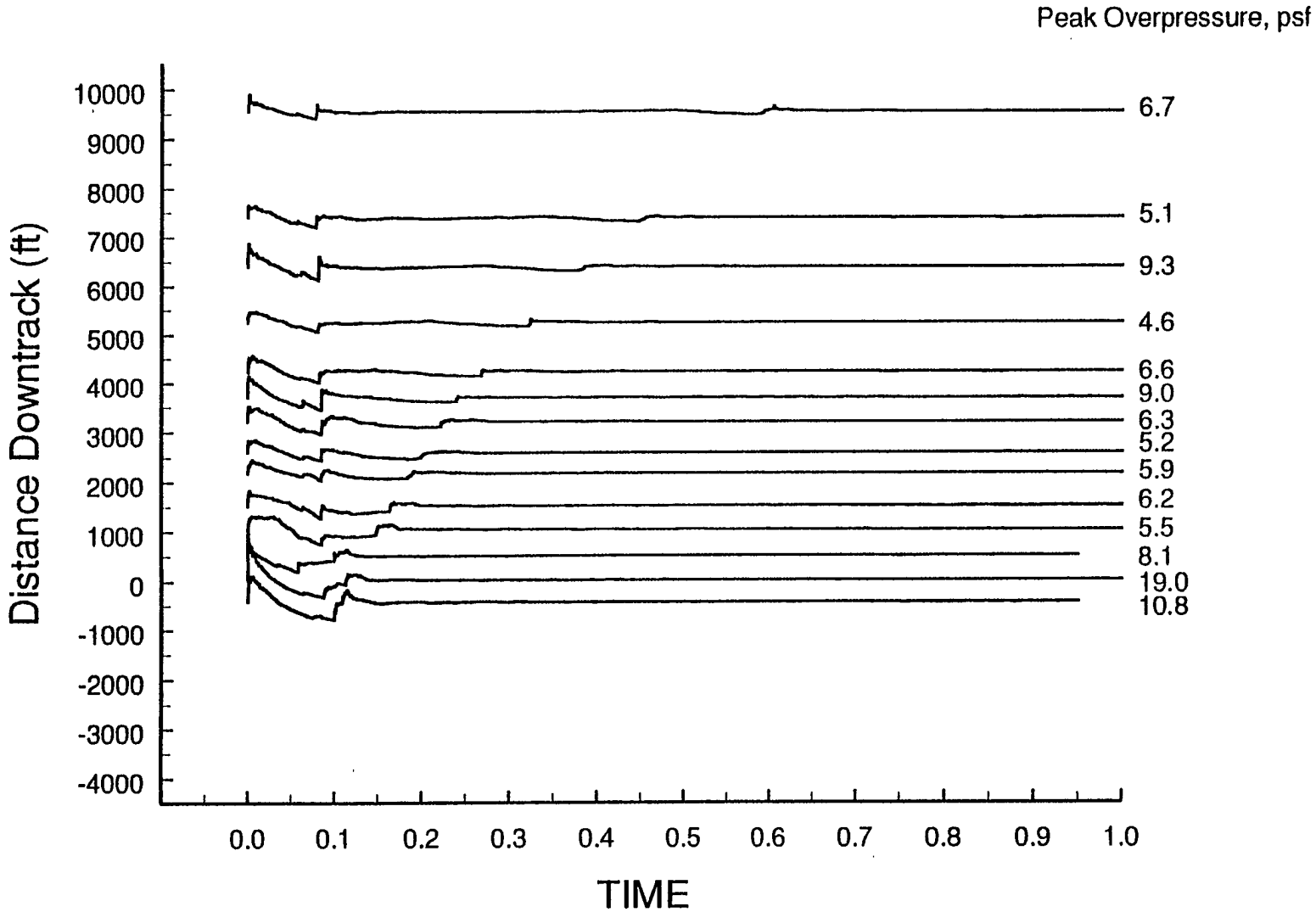

Figure C-31 Sonic boom signatures from pass 46, level acceleration (autonomous)

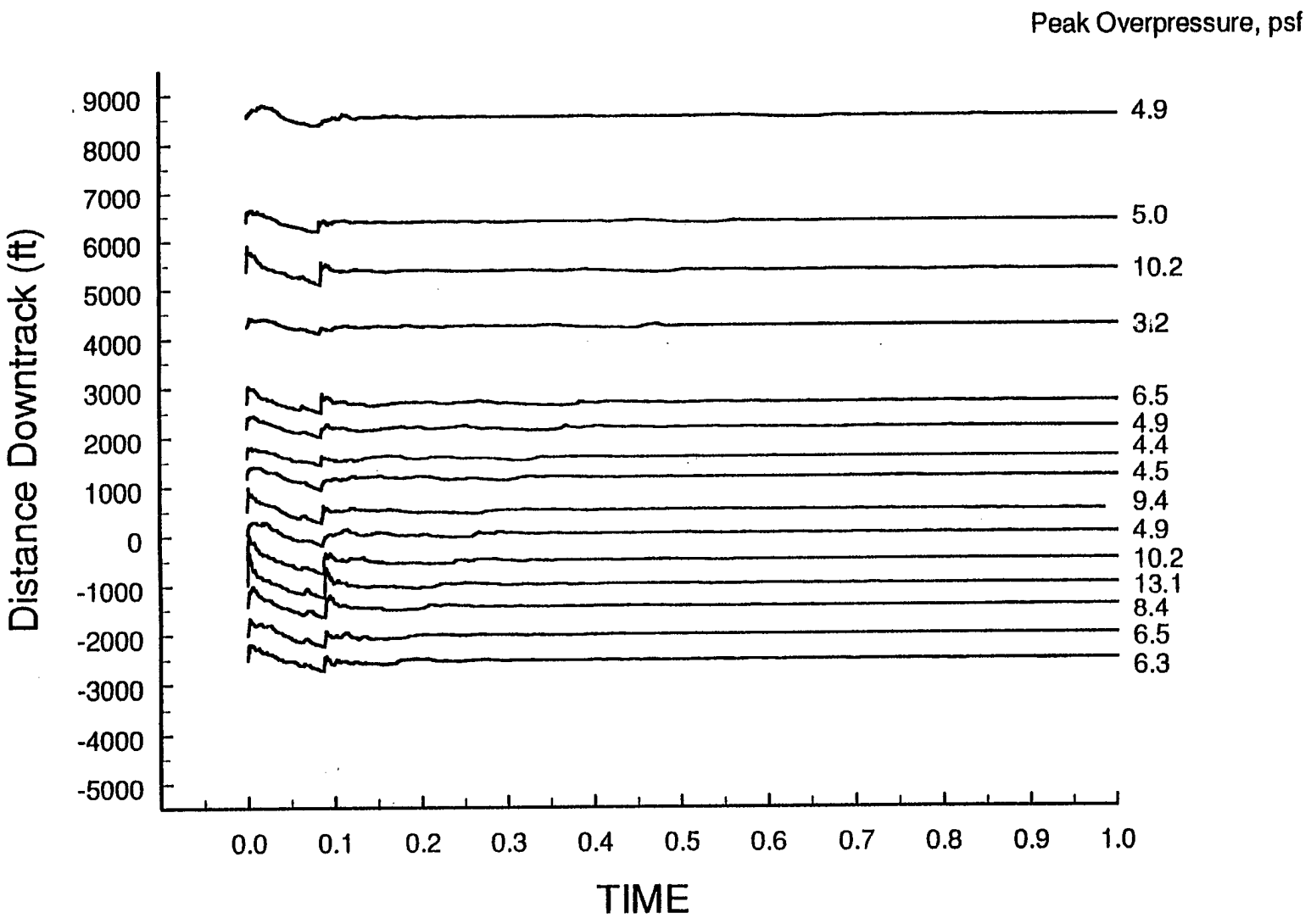

Figure C-32 Sonic boom signatures from pass 47, level acceleration (autonomous)

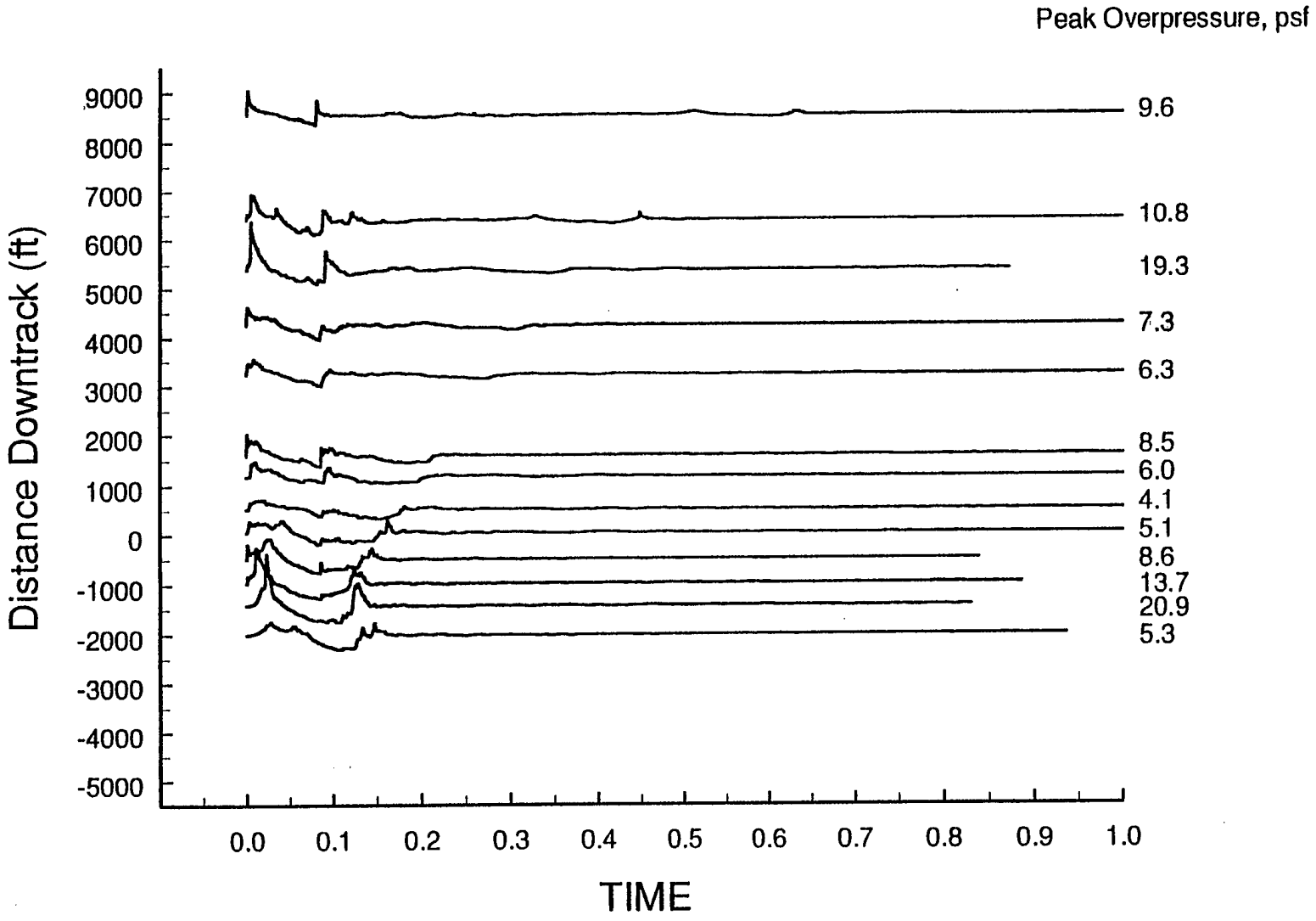

Figure C-33 Sonic boom signatures from pass 48, level acceleration (autonomous)

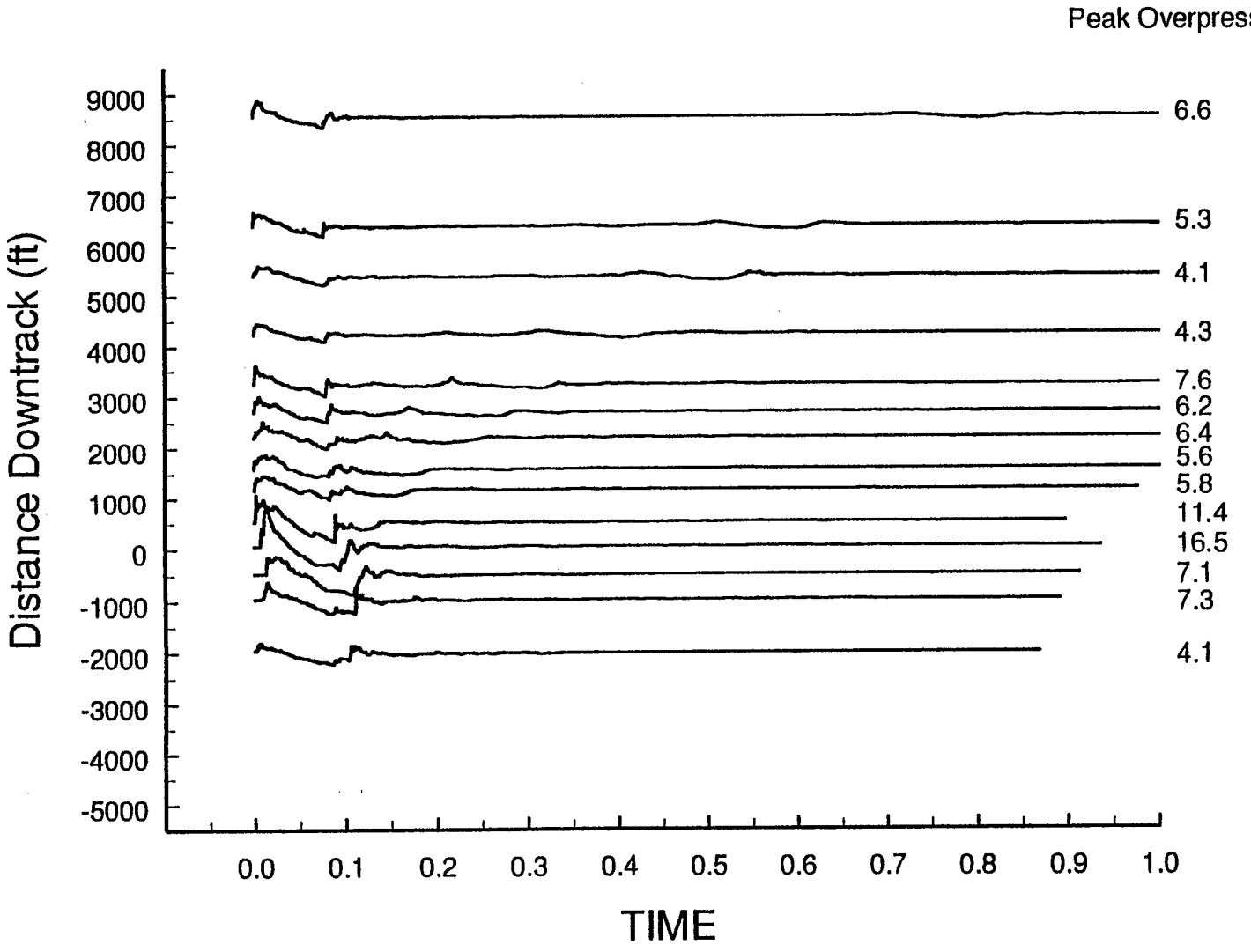

Figure C-34 Sonic boom signatures from pass 49, level acceleration (autonomous)

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APPENDIX D: FLIGHT CONTROLLER NOTES

Tues. 4/12/94 DJM

HAVE BEARS PROGRAM
MAGLIERI NOTE FROM RIDLEY CONTROL CTR

1. **Flight Missions:** Linear Accelerations-nominal conditions: 10000' MSL @ M 0.9 to 1.2

2. **Test Frequency:** 123.15 MHz (VHF)

3. **Test A/C F-16B:** Tail # 635/cobra 64/squawk 002 and tail # 099/cobra 71/squawk 081

4. **Space Position:** ARDS PODS/no FPS 16's

5. **Weather Info:** Rawinsonde launches @ 0830 and 1200 hrs. sunny, clear, high scattered low winds pretty day

6. **Nominal T/O times:** 0830 hrs and 1200 hrs

7. **Summary Highlites:** Excellent test day/results- 13 runs- captured focus boom within BEAR array on all runs-adjustments made to maneuver point (MP) worked well in locating "focus boom" within array. Good tracking data on all runs except last 3 passes because of ARDS problems (had to rely on FAA radar). However, Ridley believes ARD'S info OK-problem was between Ridley 1st and Ridley 2nd floor control, sharpcrisp and clean N-Waves measured. Had some problems with "new BEARS", lost some stations. May also have problems getting data off "Old BEARS". Could affect test objectives.

* Ridley did not inform pilots of (MP) adjustments (ie ±2000'/3000'). For all future ops Ridley will inform pilots of distance from "MP" to "T'.

* On first few runs of CB64, a/c responded to (MP) by going into A/B at countdown call. On later CB71 flights, pilots anticipated approx. 3 sec required for A/B to fully establish and were going into A/B at (MP)-3 sec. For future runs pilots will respond to Ridley countdown as CB64 did.

* Pressure altitude on both a/c about 200'/300' ft higher than Ridley reference but was held very constant.

* Except for run 1 and runs 11,12,13, ground tracks were essentially right on desired track (±0. 1 n.mi.).

8. **Run Specifics:** **Run 1** /CB71/16:23:27 "MP" based upon 0.28g accel rate (x=44700'). Good Boom signatures. Focus somewhere in middle of BEAR array. A/C north of track ~1 n.mi.
Run 2 /CB64/16:29:01 "MP" based upon 0.28g accel rate. Good Boom signatures. Focus somewhere in middle of BEAR array. A/C on track.
Run 3 /CB71/16:32:12 "MP" based upon 0.28g accel rate +1000' (ie further from target). Good Booms. Focus moved more towards (0,0).
Run 4 /CB64/16:35:32 "(MP+1000')" ie same as Run 3. Good Booms. Focus closer to (0,0). A/C right on track
Run 5 /CB71/16:39:06 "(MP+2000') ie-closer to target point
Good booms. Focus near (0,0) Grd track right on desired track.
Run 6 /CB 64/16:43:55 "(MP+2000')" ie closer to target
Good Booms. Focus near (0,0)-end runs-a/c out of fuel.
Grd track ~1/4 n.mi north target. End ops 0954hrs. PDT.

1200 hrs ops John Burchuck was controller

Run 7 /CB64/ 19:10:20 "(MP based upon 0.28g accel rate) Good Booms. Focus @ *~site 17* BEAR. Grd track slightly north ~1/4 n.mi.
Run 8 /CB64/12:16:43 (MP+2000 -ie 2000' further from target"T") Good Booms. Focus @ *~site 11*. Grd track ~1/4 n.mi north to ~1/8 n.mi.
Run 9 /CB64/19:23:22 "(MP+2000' -ie 2000' further from target "T") Good Booms. Focus @ *~site 11*. Grd track ~1/3 n.mi north.
Run 10 /CB64/19:27:36 "(MP+2000' --further from target "T") Good Booms. Focus @ ~ 0,0 Grd track ~1/8 n.mi north (note: last "quicky" run from a/c).
Run 11 /CB61/19:53:17 "(MP+3000' ie 3000' further uptrack from target point "T"). ARD Pod data bad-using FAA track - ARD Pod ~10n.mi. behind FAA position. A/C way north(~ 2n.mi) of track on diagonal. Pretty rough tracking data. Booms observed. Data O.K. if Grd track available
Run 12 /CB61/19:59:39. Still have ARD Pod problem. Grd track parerel to desired Grd track but about 1 n.mi north. "MP" same as Run 11 --ie "MP" is based upon 0.28g+3000' (ie-further away from target "T"). FAA vectoring really rough. Focus boom ahead of site 01.
Run 13 /CB61/20:05:26. Still have ARD pod problems. Grd track parallel to desired track but about ~1/4 n.mi north of desired track. Ridley is trying to get C-band/F16 on a/c for next run but to no avail. a/c out of fuel and returning to base. MP @ 0.28g-2000' closer to target point "T".

Note @ 1315 hrs Ed Bishop of Ridley called and said that "Mary" believes ARD'S pods data is O.K. and problem was between Ridley 1 st floor and Ridley 2nd floor (where controllers are

located). So we may be "O.K." on space positioning data for runs 11,12, and 13. "Mary" of Ridley is to confirm data value.

Final Note: Local PDT = Zulu time - 7 hrs

"HAVE BEAR"

Times of A/C Over IP and Target

Linear Accels of Tues 4/12/94 (PDT = zulu - 7 hrs)

Run	IP	Target (zulu)
1	16:22:48	16:23:27
2	16:28:23	16:29:01
3	16:31:34	16:32:12
4	16:34:28	16:35:22
5	16:38:03	16:39:06
6	16:41:58	16:43:55
7	19:09:13	19:10:20
8	19:15:33	19:16:43
9	19:22:17	19:23:22
10	19:26:32	19:27:36
11	19:52:03	19:53:17
12	19:58:39	19:59:39 (based on FAA radar)
13	20:05:26	(at maneuver pt. -approx.)

Wed 4/13/94 DJM

"HAVE BEARS" PROGRAM"
MAGLIERI NOTES FROM RIDLEY CONTROL CENTER

1. **Flight Mission:** A) 30° Dives - nominal conditions: 20,000' MSL @ M 0.9 to 1.2, 0900 hr schedule.
B) Linear Accel's - nominal conditions: 10,000' MSL @ M 0.9 to 1.2. 1200 hr schedule
C) Linear Accel's - nominal conditions: 10,000' MSL @ M 0.9 to 1.2. 1500 hr schedule

Note: 1500 hr missions cancelled at request of Dr Micah Downing (see comments at the end of this report)

2. **Test Flight:** 123.15 (VFH)
3. **Test A/C F-16B:** Tail #088/Cobra71/squawk 002and tail #635/cobra 61/squawk 081
4. **Space Positioning:** ARDS PODS/ No FPS 16's
5. **Weather Info:** Rawinsonde launches @ ~0900 hrs and 1200 hrs
6. **Nominal T/O Times:** 0900/1200/1500 hrs
7. **Summary Highlites:** Excellent test day/results -16 runs (9-30° dives & 7 linear accel's). Pretty we captured focus booms within BEAR array on 80% of all runs-adjustments made at maneuver point (M.P.) worked well in locating "focus" boom within ~8000' array. Note that only 19 total 45 BEAR systems were deployed for todays tests and these were located along track centerline with 500' and 1000' spacings. Good tracking data on all runs except initial portion of Run 15. However, ARDS info O.K. from (MP) to (target) in this run. Sonic booms observed ranging from "rumbles/engine noise" to "sharp crisp" single and double booms. Signature data acquired on all 19 BEARS in todays array.

* 30° dive angle runs appear within 0°to 3° of desired angle.

* Ridley did inform pilots of distance from (MP) to (T) for each supersonic run as adjustments were made based upon BEAR array audible observations.

* Pressure altitude on both A/C slightly higher than 20,000' and 10,000' MSL based upon Ridley datum (21,000' vs 20,000') and (10,500' vs 10,000').

* A/C ground tracks varied from desired track. About 50% O.K. For 30° dives, lateral offset @ target (T) varied from 0. 1 n.mi to 1.0 n.mi . For linear accels offsets varied from near zero to about 0.5 n.mi. Heading could be improved upon. Ridley controllers changed twice today. Amazed that 30° dive (MP) to (T) distance were varied from nominal 17,600' to as much as 30,500'.

* BEARS were involved recording booms from 2 NASA F- 18 A/C flying mission for NASA LaRC (Dr. Weinstein outdoor schlierin technique. No DATS were available. Flights had T/O time of 0830 and completed misssion by 0930 hrs. BEARS recorded

booms from M 1.4 @ 35,000' but signatures suggest acceleration effects. NASA DFRC plans to fly some missions Friday 4/15/95.

* Decision by Micah to "scrub" 1500 hr missions was based upon need to review "BEAR" info to assertain influence of earth's boundry layer turbulence on sonic boom signatures related to linear accels. We haven't seen any BEAR results since 1st series of flights. Tues 4/12 and description of observed booms along mic array not completely revealing/informative. Besides, there is a slight concern for longevity of 19 BEARS.

* I believe that all pilots are getting so good at flying the linear accels + pushovers that they can do most ops on their own.

8. Run specfics: (Micah pass #14)

Run 1 CB71/16:42:1 1. "MP" based upon 0.80g accel rate MP dist to T=17,500'. Micah indicated low surface winds & observed rumbles and engine roar @center of BEAR array. Ken P at west end array observed booms. Good Grd track from "MP" to "T" (target)

Run 2 CB71/16:47:41 MP to T= 19,500'. Micah heard rumbles & engine noise at center BEAR array and Ken at west BEAR array heard sharp double boom. I believe focus boom on this run captured within array. A/C track ~0.8 n.mi north track at "T" and 0.5 n.mi at "MP".

Run 3 CB71/16:52:53. "MP" to "T"=23,500'. Micah heard rumble/rumble/thunder. Grd track 0.2 n.mi north track of "MP" and ~0.5 n.mi. north at "T". Dive profile almost dead on desired. I believe focus boom placed within the BEAR array.

Run 4 CB71/16:57:23. "MP" to "T"=28,500'. Micah observed 2 sharp cracks +boom. Site 11 double boom. *Site 05* double boom-double boom, Micah indicated that all BEAR are functioning properly. Pretty good Grd track, on at "MP" and ~0.2 n.mi north at "T".

Run 5 CB 61/ 17: 1 0:00. "MP" to "T" =29,500' (based upon Run 4 of A/C 1). Lost ARDS Pods data using FAA radar track. Micah heard double boom + distance thunder.Ken P. heard 2 Big Booms.

Run 6 CB61/#635/17:19:24. "MP" to "T" = 25,500'. ARDS Pod data back on-line. Micah heard double boom-boom. Sta: "01" 2 big booms. Sta "05" 2 booms + trailing "pops" and Ken P. 2 booms + trailing "pop". Grd track ~0.2 n.mi South at "MP" and 0.5 n.mi South of "T".

Run 7 CB61/17:25:56. "MP" to "T"= 25,500'. Micah heard 2 big booms and "pop". Sta "01" - 2 big booms, Sta"05" 2 booms and rumble. Grdtrack ~0.2 n.mi south track at MP and 0.8 n.mi. south at "T". Dive angle right on 30°.

Run 8 CB61/17:28:28, (time over " T"). "MP" to "T"=30,500'. Micah heard 2 booms and"pop". Sta. "01" heard 2 big booms and noise. Sta "05" 4 booms. Ken P heard boom-boom and weaker

"pop". Dive angle on 30°. Grd track ~1 n.mi south track all the way.

Run 9 CB61/17:35:50. "MP" to "T"=27,500'. Micah observed double boom and double "pop" Sta. "01" 2 booms and "pop" Sta. "05" 2 booms and "pop". Ken P 2 booms and small "pop". 30° dive angle right on. Grd track ~0.3 n..mi and 0.7 n.mi to south at "MP" and "T" respectively.

*"End 30 Degree Dive Ops"

*"Begin Linear Accels"

Run 10 CB61/19:34:47. "MP" to "T" = 44,700' (based upon 0.27g accel rate. Nominal selection for heavy weight A/C. Micah said WX calm at surface. Sta "01" heard 2 booms and A/C noise. Ken P heard 2 booms only. Good Grd track on at "MP"and ~0.2 n.mi south at "T." Altitude 10,300' vs 10,000' @ Ridley.

Run 11 CB61/19:40:23. "MP" to "T"'= 41,700'. "BP" to west beyond "T". Wind at meas. sites picking up. Micah heard rumble + 1 boom + rumble. Sta"01" heard thunder and flyover noise. Sta "05" boom boom + A/C noise. KenP bang-bang and noise. I believe good run with focus in BEAR array. Grd track essentially on.

Run 12 CB61/19:45:16. "MP" to "T"= 42,700'. Micah said winds picking up again. Pilots noted no turbulence at altitiude. All 12 runs so far show A/C pretty much matches Ml point calculated. Micah heard rolling thunder and double "Pop". Sta "01" start of boom and rumble. Sta "05" 2 very intense booms. Ken P heard 2 booms and slight pulse. Ground track is on at "MP" and ~0.5 n.mi north at "T".

Run 13 CB64/19:49:48. "MP" to "T"'= 43,700'. Micah heard distant thunder overhead. Helicopters overhead at ridge. 1st pass @ higher weight of A/C 2. Grd track parallel to desired track ~0.1 n.mi north.

Run 14 CB61/19:52:09. "MP" to "T" = 41,700'. A/C really "hot" on accel. Last "squeeze" in run of a/c 1. Micah heard rumble and boom-boom. Sta"01" heard 2 sharp booms. Sta"05" intense boom boom. Ken P bang-boom boom. Grd track and hdg great. A/C ~0.1 n.mi north of track all way.

Run 15 CB64/20:00:43. "MP" to "T'= 41,700' since a/c is higher wt. we need to move focus line toward Ken P (west end of array). Lost ARDS prior to and near I.P. and got it back at "MP". Micah heard rumble and boom-boom. Sta "01" 2 dull booms and flyover noise. Sta "05" 1 boom explosion. Ken P good double boom and whistling jet noise. Grd track ~0.5 n.mi north at "MP" and 0.2 n.mi south at "T":

Run 16 CB64/20:05:42. "MP" to "T"= 40,700'. Micah observed rumble andboom. Sta"01" a rumble and flyover. Sta"05" also rumble and flyover. Ken P heard boom plus flyover noise. Grdtrack ~0.2 n.mi south track of "MP" and ~0.5 n.mi south track at "T". Correction given for 10 degrees right @ m1 point.

End Linear Accel Runs"

Note: Micah recommended we cancel 1500 hrs ops for reasons given previously. Concurred by TPS
Note: Local PDT = Zulu - 7 hrs.

Times of A/C Overhead of Target
(Local PDT = Zulu - 7 hrs)

Run		Time at IP (zulu)
1	16:42:11	16:41:19
2	16:47:41	16:46:50
3	16:52:53	16:52:02
4	16:57:23	16:56:33
5	17:10:00	Lost ARD Temp
6	17:19:24	17:18:34
7	17:25:56	17:23:03
8	17:28:40	17:27:51
9	17:35:50	17:35:01
10	19:34:47	19:33:34
11	19:40:23	19:39:08
12	19:45:16	19:44:10
13	19:49:48	19:48:40
14	19:52:09	19:51:00
15	20:00:43	19:59:00
16	20:05:42	20:04:32

End Tests

Fri 4/15/94 DJM

HAVE BEARS PROGRAM
MAGLIERI NOTES FROM RIDLEY CONTROL CTR.

1. **Flight Missions:** 50° turn entry maneuvers (nominal conditions: 10,000' MSL, M 1.2entry, 4g turn).
2. **Test Freauency:** 123.15 MHz (VHF)
3. **Test a/c (F-16B):** Tail #635/CB64 and 099/CB71
4. **Nominal T/O time:** 1200 hrs and 1500 hrs
5. **Space Positioning:** ARD'S/no FPS 16
6. **Weather Info:** Rawinsondes scheduled 1200 and 1500 hrs. Sunny and clear surface winds 7- 10 kts in late AM.

7. **Summary Highlites:** Very good test day/ results. Acquired sonic boom data on all 4 runs (2 passes/sortie). Positioned focus boom within the BEAR linear array of ~19 positions. All functioned today. Positioned maneuver point based upon M = 1.2 and 4g condition. A/C were pretty much on Mach, g, and altitude. Headings and plan position within ±0.5 n.mi of desired run-in line. Lost ARD'S on CB71 (1st floor/2nd floor Ridley problem again) and relied on ATC track. CB64 O.K. Based upon boom observations, "MP" moved west 1000'-2000' after Run 1 to reposition focus boom.

* Runs were ~3 min apart which permitted little time to acquired test site observation for feedback to pilot on "MP" to "T" distance changes. Previous days of testing runs were 5-6 min apart.

* Was a mix up in "X" distance (between MP and T) definition but did not affect ops since pilots took countdown que from Ridley.

* On all 4 runs, a/c entered at 1.2+ at "MP" and exited at M 1.19 and 1.18, 1.2, and 1.2 for runs 1,2,3, and 4 respectively. 4g's essentially held throughout 50° turns.

* Flt altitude was pretty much at 10,000' MSL. Run 2 was at about 9,300' MSL.

* Bishop stated that 3 of 4 ARD'S receivers were down and that the one working was too low altitude to do a reasonable job.

* Because of ARD'S receiver problems and Micah's concern for BEAR stability, it was decided to scrub 1500 hr missions.

* Micah supported NASA F-18's 2 sonic boom runs at 0900 hrs with 4 BEARS and a DAT located ~1000' from Hwy 395. Activity related to "outdoor" schlieren photos of shock flow field (M 1.4 @ 35,000' MSL).

8. **Run specifics:** **Run 1** CB71/19:18:28. "MP" based upon 4g turn at M 1.2 entry (Micah's Pass #30) with "x"(distance from MP to T) = 60784'. Observations- going from east to west ends of BEAR array: Carey @ sta "01" observed 2 booms, Bob M @ "05" boom plus flyover noise, Bob Lee @ sta "08" a Ba boom and rumble,Mike P @ "11" a boom boom and rumble, and Ken and Micah @ sta "19" heard 3 pops rapid fire. Lost ARDS. Plots using ATC. a/c ~0.5 n.mi N of

track @ MP and passed slightly west array following BP. Hdg 270° T and alt ~10k MSL. M 1.2 @ S.P. and 1.19 @ B.P.

Run 2 CB64/19:21:39. "MP" moved 1,000' west. Distance to target "x" = 59784'. Observations were: Carey @ sta "01" one boom, Bob M @ "05" 2 big booms plus flyover engine noise, Bob Lee @ "08" a Ba-Ba Bang and a/c noise, Mike @ "11" two quick booms and flyover noise and Ken and Micah @ "19" one big boom. Good track. Had ARDS. a/c ~0.1 n.mi north of track and passed directly over array. Alt ~9,300 MSL. M 1.2 @ MP and M 1.18 @ B.P.

Run 3 CB71/19:24:45. "MP" moved another 1000' west. "x" = 58784'. Observation were: Carey@ sta "01" heard a boom, Bob M @ "05" a Ba-Boom and flyover noise, Bob L @ "08" a double boom and flyover, Mike @ "11" a boom-boom more intense than Run 2, and Ken and Micah @ "19" a Ba-Boom. A/C hdg ~265° T and 2 n.mi north track at MP and passed about l n.mi. west array of following turn at B.P. M 1.2 @ SP and B.P.

Run 4 CB64/19:28:45. "MP" kept same as for Run 3. "X" distance from MP to T =58784'. Boom observation were: Carey @ "01" two booms, Bob M @ "05" 2 sharp booms and flyover, Bob L @ "08" two double booms louder than Run 3, Mike @ "11" Boom-Boom and rolling thunder noise, Ken and Micah @ " 19" a Big Boom. Good ARDS data. A/C hdg ~275° T. On track @ SP and ~0.25 n.mi north at MP and passing ~0.7 n.mi west of BEAR array. M 1.2 @ S.P. and B.P

"End of Today's Ops- 1500 hrs Ops Cancelled"

"HAVE BEARS"

F- 16 Sorties of Friday 4/15/94 - Turn Maneuver

"Test data times of a/c over I.P. and B.P"
(ZULU; PDT= Z - 7 HRS)

Run No.	Time @ **I.P.**	Time @ **B.P.**
1	19:16:46	19:18:28
2	19:19:56	19:21:39
3	19:22:58	19:24:25
4	19:26:39	19:28:45

Mon. 4/18/94 **DJM**

"HAVE BEARS" PROGRAM
MAGLIERI NOTES FROM RIDLEY CONTROL

1. **FlightMissions:** 50° turn entry maneuver (nominal conditions: 10,000' MSL M 1.2 entry with 4g turn).
2. **Test Frequency:** 123.15 MHz (VHF)
3. **Test A/C (F-16B):** Tail # 635/cobra 61 (Maj Chung/ Capt Morin)
4. **Nominal T/O Time:** 12OO hrs (Times in Zulu, PDT = Z-7 hrs)
5. **Space Positioning:** ARDS POD
6. **Weather Info:** Rawinsonde scheduled 1200 hrs. Wx sunny and clear w/few clouds pilot reported no turbulence @ alt and low surface winds @ BEARS.
7. **Scheduled Missions:** 1 a/c for 50° turns @ 1200 hrs and 2 a/c for autonomus linear accels @ 1500 hrs. 1500 hr missions cancelled due to closed runway (C-17 brake/tires/strut) until at least 1800 hrs.

8. Summary Highlites: Excellent test day and measured results. Acquired sonic boom signatures on all three (3) runs from essentially all 28 BEAR 13,000' linear array. Believe we positioned the turn entry focus on targeted BEAR location on Runs 2 and 3 (Run 1 was aborted by pilot just prior to MP due to instr. problems. Just as well since Ridley again lost ARDS on first pass.) BEAR array and flight track similar to 50° turn ops of Friday 4/15/94 with exception of displacing a/c track another 1,300' to south (y = 11,000' vs 9,700') Distance from MP to T also changed slightly (from 60784' to 62500').

* On both 50 degree entry runs (Runs 2 and 3) a/c was also 0.2 n.mi and 0.3 n.mi. North of track on desired 270° T heading, on altitude of 10,000' MSL, and at M 1.2 @ S.P. A/C entered turn at M 1.2 at MP and M 1.19/1.18 @ BP. Turn 'g' entry 4.0 and 4.3 @ BP.

* After 1200 hrs ops Micah downloaded some of BEARS and results indicate the focus was observed and pretty much at designated target location.

9. Run Specifics: (Micah's Pass #34)

Run 1 CB71/19:05:23. MP to target set at nominal valve of x=62500'. Ridley lost ARDS on a/c @ IP and relied upon ATC. A/C broke off run prior to MP due to instr. problems. Attained ~M 1.05. Booms were observed and recorded at test site. Carey (Sta '06') observed 2 separate rumbles, Mike (Sta '10') 2 bangs and boom and low rumble, Bob M (Sta '15') heard same as Mike, Ken /Micah (Sta '19') heard double boom (ie BB-BB), Bob L (Sta '23') heard thud and normal boom. A/C ~0.7 n.mi north track on hdg 270° T and little high on alt. A/C was just prior to MP when broke off run at M ~1.05 due to a/c instrument problems.

Run 2 CB71/19:11:15. MP remains same --ie x = 62500'. ARDS is back on line. Observation @ test site as follows: Carey @

"6" heard one boom (BB), Mike @ "10" I boom (BB) vary intense, Bob M @" 15" a boom (BB), Ken/Micah @ (19) 2 sharp cracks, and Bob L @ "23" 1 boom (BB) and a/c noise. Focus is probably at Mikes "10" location. A/C right on hdg 270° T and alt (10k) and only 0.2 n.mi north of desired track. a/c grd track ~0.2 n.mi East of O.H. A/C @ M 1.2 @ SP and M 1.19 @ BP. Accel 4.0g @ entry and up to 4.3g in turn to BP.

Run 3 CB61/19:17:05. MP remains same (x = 62500'). Good ARDS track. Observation @ test site as follows: Carey @ "6" heard 2 booms (BB-B), Mike @ "10" BB-B, Bob M @ "15" 2 intense bangs and lighter boom, Ken/Micah @ (19) 2 sharp double cracks, and Bob L @ "23" 1 boom more intense than Run 2. Focus is probably at Bob M " 15" site. a/c right on 270° T hdg on alt @ 10k' and about 0.3 n.mi North of desired track. Thus focus should move from Mike "10" position to Bob M " 1 5" site - and it apparently did. a/c on M 1.2 @ SP (shorter dive - run in) and M 1. 18 @ BP. Entered turn @ 4.0g and to 4.2g at BP. Ridley gave 10° left course correction prior to SP but pilot wisely ignored it. I'm convinced that these 50° ss turns can be flown autonomously and will place focus within ±1000' of desired.

"End of Today's Ops - 1500 Hrs Auto Linear Accels Cancelled
(C-17 Closed RW)

OPS TIMES FOR 1200 HR RUNS @ IP AND O.H.

Run No.	Time @ I.P.	Time @ O.H
1	19:04:02	19:05:32 (approx. ATC track)
2	19:09:17	19:11:15
3	19:15:23	19:17:05

Tuesday 4/19/94 DJM

"HAVE BEARS" PROGRAM
MAGLIERI NOTES FROM "RIDLEY" CONTROL

1. **Flight Mission:** Pull-up pushover maneuver (nominal conditions: Enter SP at M 1.2 @ 10,000 msl At C.P pull-up to 10 degrees, at MP pushover 0.5g and top out at 13,600 msl holding M 1.2 to B.P.)
2. **Test Freciuency:** 123.15 MHz (VHF)
3. **Test A/C (F-16B):** Tail # 099/Cobra 61 (Maj Chung/Cpt Morin)
4. **Nominal T/O Time:** 1200 hrs (range time in Zulu. PDT = Z - 7 hrs)
5. **Space Positioning:** ARDS POD
6. **Weather Information:** Rawinsonde launched @ 1 130 hrs. At 0900 hrs sunny and clear with high scattered clouds and low surface winds.
7. **Summary Highlites:** * Excellent test day and measured results. Acquired sonic boom signatures on 2 Runs on all 29 BEARS 13000' linear array. Measured focus boom (Δp ~3 times carpet boom) on Run I as predicted. Probability of capturing focus boom with array in Run 2 high (based upon observer remarks).

   * A/C 1st run is aborted just inside IP due to loss of ARDS data. ARDS up prior to 2nd Run. Climb and maneuver points (CP and MP) are indicated in attached sketch along with Lat/Long coords. Since pushover focus region occurs laterally to ground track, a/c run-in line was 13700' lateral to target array.

   * Ridley gave countdown to (CP) on Run 1 and 2 and to (MP) on Run 2. A/C on Mach and altitude at "SP". Hard copy tracking overlays not available- computer malfunction

8 **Run Specfics:** (Micah's Pass #37)

Run 1 CB61/19:21:00. CP to target 55800' and "MP" to target 38950'. Boom observation at test site as follows: Carey @ site "5" heard 1 Bang, Micah/Mike @ "11" 2 sharp cracks (8psf), Bob M @ "15" a sharp boom, and Bob L @ "21" 1 sharp boom. Down loaded BEAR data shows the focus (11 psf) in array. A/C track was on correct heading north of track. Entered at M 1.2 at "SP" and alt. 10,000'. At M 1. 16+ at "CP" thru "MP" and topped out @ ~13,700' MSL. Ridley gave countdown to "CP" but not to "MP".

Run 2 CB61/ 19:28:00. Repeat of Run 1 re: "CP" and "MP". Boom observation as following: Carey @ site "05" heard 2 bangs, Micah and Mike @ "11" a Ba-Boom (1 Boom), Bob M @ "15" 1 boom, and Bob L @ "23" 1 Boom. A/C track pretty much right on 270° T heading and on-line. Ml.2 at SP and thru B.P.. Countdown given at "CP" and "BP" for 10 degrees climb and 0.5g pushover, respectively. Entry altitude at 10,000' MSL. Also the climb-pushover topped out at 13.6k'. No hard copy of Ridley plot screen available.

"End of Today's OPS "

Ops Times for 1200 hrs Runs 0 IP and Target

*Not available since "hardcopies" not available

* Appox times as follows: Run 1 ~19:21:00 zulu

Run 2 ~19:28:00 zulu

Notes:

1. Capt Morin's calculations for today's maneuver were slightly different from PCB3 outputs. Specifically, distance from "CP" to target 55,800 vs 49,200 (PCB3) and distance from "MP" to target 19,200' vs 23,450' (PCB3). We used his positions.

2. Initial ARDS POD got on wrong a/c which took-off ~11:15 for structure test run 2nd ARDS POD put on #099/CB61.

3. CB61 was authorized to make autonomous linear accel run at end of 2 climb pushover runs if fuel allowed. Because of abort of initial run in to Run 1 (lost ARDS), "auto" not performed

4. @ 1130 hrs, Ridley schedule showed ops for Wed 4/20 as follows:

*0900 hrs - 1 a/c

* 1430 hrs - 2 a/c

@ 1830 hrs today we heard that Wed schedule is

0800 hrs-1 a/c
1 1 00 hrs- 1 a/c } all F-16B's 'Autom.' Linear accel
1430 hrs-1 a/c

* However: Shuttle may have to land @ EAFB @ 0950!

Wed 4/20/94 DJM

"HAVE BEARS" PROGRAM
MAGLIERI NOTES FROM RIDLEY CONTROL

1. **Flight Missions:** Level Accel's ("Autonomous") Nominal conditions M 0.9 at MP @ 10,000' Pa and Max. accel to M ~1.15. A/C info is "X" distance from MP to Target. Nothing else.
2. **Test Frequency:** 123.15 MHz (VFH)
3. **Test A/C (F-16B):** Tail # 635/Cobra 64 (Capt Moss/Cpt Vega)
4. **Nominal T/O Time:** 1500 hrs (STS landing cancelled our 0830/1100/1430 missions).
5. **Space Positioning:** ARDS POD
6. **Weather Information:** Rawinsonde scheduled- may can use launch re: shuttle landing?
   Observations at test site - winds calm, sky clear, no clouds, ~98° degrees F.
7. **Summary Highlites:** * Excellent test day and results. 1st series of autonomous runs. 1st time ever I'm aware of that "focus boom" was place on target point w/o grd. control. Down loading of BEAR data tonight will confirm Δ distance accuracy. BEAR linear array is 13000 w/target @ 4000' west of east end of array. 32 BEARS deployed.

   * Focus boom placed on target (at least within ±1000') on 2 of 4 runs (Runs 2 and 3).

   * Ridley acquired tracking data and marked pilots calls at SP, MP, Ml, and BP. All 4 runs essentially on track and on altitude. No guidance (countdown given to a/c).

   * Nominal "X" distance to target was 47,600'. A/C pretty much on @ entry Mach (M 0.9) and BP (M 1.12).

   * Major factors resulting in missed "focus booms" on Run 1 and 4 identified and anticipated.

8. **Run Specifics:** (Micah Pass #39)

Run 1 CB64/22:19:32 hrs. "MP" to target "T" distance "X" = 47,600' and based upon 0.27g accel rate (and also empricial results of 4/12 and 4/13 level accel runs). Boom observations @ test site asfollows: Bob L (Sta '19), Micah (Sta '11'), Target (Sta '09'), Bob M (Sta '07'), Carey (Sta '03'). Carey heard 2 bangs, Bob M one boom, Micah a bang bang bang, Bob Lee a large boom. Focus boom East end of array. A/C altitude 10,500' MSL. Ground track 272° T vs 270° T desired. A/C right on overhead target and ~0.2 n.mi south of track @ MP. Lovely straight run in on M 0.91 @ MP and at M 1.12 @ B.P. Ridley noted that when pilot called "MP" a/c position was at 3 sec (~3000') up track. Thus, focus boom would have hit just ahead of east end of BEAR array. Station observations indicate this is the case.

Run 2 CB64/22:25:09 - "MP" to "T" distance "X"= 46,100' (ie-1,500' closer to target due to increased accel rate at lighter a/c weight Boom observations as follows: Carey heard low rumble, Bob M. a low rumble and small boom, Micah a boom-boom, and Bob L a medium level boom followed by a/c noise. The obs. indicate "focus" occured between Micah and Bob M, ie at designated "T" position. A/C at 10,600' MSL and straight run in track on ~272° T hdg, 0.30 n.mi south of track @ "MP" and overhead at "T".

Ridley shows that countdown to MP was right on (ie-MP @ +1 sec from run 1). So focus hit as predicted. A/C @ M 0.9 and M 1. 12 @ MP/BP.

Run 3 CB64/22:30:05 hrs.- "MP" to "T' distance "x"= 44,500' (ie - closer "because of higher accel rate re: fuel bumed). Sonic boom observations as follows: Carey heard rolhng thunder, Bob M also heard rolling thunder, Micah (west of "T") heard pre-cursor rumble plus a boom-boom and Bob L, a ba-ba-boom (ie- 2 signatures in post focus). These observation indicate "focus" very near target "T". A/C on about 10,300' MSL. Hdg 272° T M 0.90 @ MP and M 1.12 @ BP. Countdown to MP right on, ie 2-3 sec after Run I MP point as planned. a/c ~0.4 n.mi south @ MP and overhead at "T"

Run 4 CB64/22:35:33 Z - "MP" to "T" distance"x" = 42,900' (ie closer t target based on assumption higher a/c accel rate). Sonic boom observation as follows: Carey heard rolling thunder, BobM also heard rolling thunder, Micah heard distant boom w/rumble, and Bob L thunder and a/c noise. Appears that focus was placed west of BEAR array but signatures shows focus to be within array. Lower atmosphere turbulence/thermal effect seems to be causing "defocussing" (as was observed in NASA boom tests of 1964). Signatures measured on today's runs are very "spiked" and "disturbed". A/C high on altitude (10,600' MSL), hdg 273° T ~0.5 n.mi south of track @ MP and slightly north of target. A/C entered @ M 0.89 at "MP" and M 1. 12 @ B.P. "MP" hit right on countdown (ie - + 5 sec. after MP for x = 47,600')

"End Level Accel. "Auton" Runs Today"

Ops Times From Ridley Plots for a/c IP and Target (Zulu)

Run	Time @ IP	Time @ target
1	22:18:25	22:19:32
2	22:24:00	22:25:11
3	22:28:43	22:30: 07
4	22:34:04	22:35:33

Final Notes:

1. Results of today clearly demonstrate need for early AM "Autom" level accel's - ie - need for boom signatures that are not distorted due to "earth's boundary layer" turbulence (lst 1,500' - 2,000' from surface).

2. Post look at today's 4 runs (Chris' HUD data and BEARS signatures) convinces me that "focus"boom should have been and was placed near "target" (Run I should have occurred east of array because of early 3 sec mark at MP). The randomness of lower atmosphere is acting to "defocus" the "focus". For max focus to occur, everthing must be

more or less, "in phase," ie quiesient atmosphere like exists in early AM hours when strong temp. inversion exists in lower layers of atmoshere.

3. BEARS recorded shuttle booms @ about 0954 hrs local time. Δp's ~1.0 to 1.9 psf. STS hdg roughly SSE some 18 mi west of array. STS at ~ 70,000 + ft and M ~1.4. Will get tracking info from Ridley.

4. Appears to be - 1.0+ sec discrepancy between "x" distance to target based upon latitude and longitude of "MP" and "T"' vs distance "x" from target latitude/longitude to "MP".

Info on Autonomous Level Accel's of Wed 4/20/94

Ground rules:
1. Pilots will be given distance "x" from "MP" to "T" for each run.
2. Ridley will track all "Auton" runs and turn data on 10 sec prior MP and after BP.
3. Pilots are requested to call out "MP", "MI", and "BP".
4. Run in to manuever pt (MP) is @ M 0.9 and 10,000' Pa.
5. At "MP" throttle will go to max A/B (no anticipating 3 sec req'd to T max) since "x" (distance from MP to T) is based on this condition.
6. "BP" is @ M 1.15
7. "T" target is established 4,000' west of end of 13,000' BEAR array.

THUR 4/21/94 DJM

"HAVE BEARS" PROGRAM
MAGLIERI NOTES FROM RIDLEY CONTROL

1. **Flight Mission:** Level accel's (Autonomous) - Nominal conditions: M 0.9 at maneuver point @ 10,000' Pa and Max accel to M 1.15. Only info to a/c is "x" distance from "target" to "MP"
2. **Test Frequency:** 123.15 MHz (VHF)
3. **Test a/c (F-16B):** Tail # 099/Cobra 61 @ 0730 hrs (Maj Chung/ Capt. Morin)
   Tail # 099/Cobra 64 @ 1630 hrs (Capt Moss/ Capt Zamot)
4. **Nominal T/O Time:** 0730 and 1630 hrs.
5. **Space Positioning:** ARDS POD
6. **Weather Information:** Rawinsonde launched @ 0700 hrs and 1600 hrs. Clear skies. Surface winds @ 0630 and 0930 - 15 kts gusty at Ridley. At 0750 Cobra 64 reported little turbulence with ~25kt. crosswind at altitude of 10,000 Pa. At meas. site Ken reported cool and clear with low surface winds (@ ~0730 hrs). For PM runs, clear skies, 7 Kt surface winds at test site gusting to 25 Kt. Strong westerly winds. Pilot reported there was little turbulence at altitude but stiff winds.

7.Summary Highlites: * Excellent test day and results. 2nd and 3rd series of autonomous level accelerations. Total of 2 sorties (0730/1630) with 4 and 3 runs each. Of 7 runs, focus placed @ T, T-500', and T- 1,000' on 4 of them. Other 3 runs, focus between T-2,000'/4,000'. Had some 32 BEARS in ~13,000' linear array with 90 % functioning. Although "T": distances varying, test objectives are considered accomplished.

* 1st order effect regarding autonomous ops and focus placement relate to more complete knowledge of a/c acceleration rates and initiation of "MP". Influence of atmosphere effect on boom propagation/signatures distortion,the small a/c heading, altitude and lateral displacement from desired run-in track are felt to be of 2nd order effect. Effect of atmos (esp. Temp) on a/c accel rate very important.

* PCBoom3 prediction is believed to be appropriate to placing focus booms to within ±500'. Knowledge of a/c performance on any given day and pilots consistency of operations are key to achieving this objective.

* This writer is convinced that the prediction and placement of the controlled "focus" sonic boom is a "given" and has demonstrated. Although only "autonomous" level accelerations have been conducted, it is believed that turn entry, dive and pullup-pushover maneuver can also be accomplished "autonomusly".

* A/C heading for 0730 ops, as per 1530 ops of yesterday (4/20) consistently ~4° off (274° T vs desired 270° T hdg). A correction to mag hdg for today's 1630 hrs ops resulted in actual track being ~272° T.

* ARDS Pod data acquired on all 0730/1630 ops. However, hardcopy of tracks only available for last run of 0730 flts and all 3 runs of 1630 ops.

* On essentially all 0730/1630 ops, Ridley "mark" of a/c call on "MP" shows a/c initated "MP" ~ 1.5 to 2.0 sec. early. Maybe our problems is in actual "MP" established by "Ridley" vs MP established by "HUDS".

* PCBoom3 was used to predict change in a/c accel rate and focus location. Was assumed 0730 hrs ops would experience cooler temps. than 4/20 1530 ops. Predictions suggested a +600' change in "x" distance from Target to "MP." Pre-flight rawinsonde inputs to PCBoom3, esp. re: a/c perform accel. rate would have provided even greater success to focus placement.

8 Run Specfics: (Micah Pass #43)

Run 1 CB61/14:40:58 hrs - "MP" to"T" distance "x" = 47,600' (as pre-planned) and was based upon 0.27g accel. rate and also on our emperical findings from analyzing ops of 4/12, 4/13, and 4/20 ops for level accels. Boom observations at test site as follows: Bob L (Sta '19'), Micah (Sta '11'), Bob M (Sta '07'), Carey (Sta '03'). Target 4,000' west of east end BEAR array. Carey 3,000' east of target. Bob M is 1,000' east of "T". Micah 1000' west of "T". Carey @ "03" heard 2 bangs close together, Bob M @ "7" 3 sharp booms close together, Micah @ "11" 3 sharp cracks, and Bob L @ "19" a bang-bang -pop. These observations suggest focus is near east end of array (T-4,000'). Lost ARDS on inbound so its difficult to tell countdown to MP but Dennis (controller) said it was right on a/c alt,~ 10,400' MSL, hdg ~274° T vs 270° T desired ~2.0 n.mi south track at IP, 0.35 n.mi. at MP and 0.3 n.mi. north at O.H.

Note: (Examination of BEAR data @ 1530 hrs in-field shows focus @ ~ T - 4,000')

Run 2 CB61/14:47:00- "x" distance to target reset to 45,000' (vs preplanned 46,100') based upon Run I observations. Adjusting for a/c higher accel. rate due to cooler atmosphere and fuel burn wt. decrease. Boom observations were: Carey @ "3" heard rumble, Bob M at "7 " a sharp boom, Micah @ "11" rapid fire 3 sharp bangs, and Bob L @ "19" triple bang. These obs. suggest focus very near target (~T-500'). Dennis said "MP" called ~1.5 sec. early re: his plot a/c ~2.0 n.mi S. track at IP, 0.3 n.mi S. @ MP, and 0.35 n.mi N. @ O.H. Results of this run suggest Run 3 "x" distance be reduced (more MP closer to target)

Note: (Examination of BEAR data @ 1530 hrs in - field shows focus at - T-500')

Run 3 CB61/~14:52:34- "x" distance at 43,500' (vs pre-planned 44,500') based upon Run 2 observations and a/c higher accel rates. Boom observations as follows: Carey @ "3" heard 1 bang, Bob M @ "7" 1 bang, Micah "11" 3 sharp cracks, and Bob L @ " 19" a ba -boom pop. These observations suggest focus at near east end of array (~ T-4,000') but it should have been nearer to "T". Dennis said a/c call on "MP" about 2 sec early. We can't be this far off in our calc. Need to look at BEAR measurements vs. observations.

A/C @ ~ 10,400' MSL, 0.35 n.mi S. track at MP and 0.35 n.@ N. @ O.H.

Note: (Examination of BEAR data @ 1530 hrs hrs in the field show focus at T-2,000').

Run 4 CB61/~14:58:06- "x" distance set at 42,000' (vs. pre-planned 42,900'). We figured if a/c is hitting MP 2 sec too soon (~ 2000') then focus should be right on w/this run. Boom observations as follows: Carey @"3" heard 1 bang and rushing noise, Bob M @ "7" 2 sharp bangs, Micah @"11" 3 pops ie. boom-boom-boom, and Bob L @ "19" a boom-bang. Observations suggest focus @ T-3,000'. Short again and shouldn't be. Dennis indicated same 2 sec's early on "MP". A/C ~ 0.25 n.mi south @ MP and 0.25 n.mi N. @ O.H.

Note: (Exaniination of BEAR data in the field at ~1530 hrs show focus is right on "T" with overpressure of 19 psf (focus factor ~ 4.5!). So things do work!

End 0730 hrs "Auton" Level Accel's

Start of 1630 hrs "Auton" Level Accels

Note: As a result of 0730 level accel runs, esp: BEAR signatures, we all agreed to shorten the nominal "x" distances to target by 1,000' (ie-for Run 1- 46,600' vs 47,600'; Run 2 45,100' vs 46,100', and Run 3 - 43,500' vs 44,500'. This is being done mainly to provide more BEAR positions east of target. A/C keeps same target coordinates and we place focus at T + 1000') or Micah's "11" position". Micah noted wx at site clear and sunny with winds ave. 7 Kts and gusting to 25 Kts.

(Micah's Pass #47)

Run 1 CB64/23:51:50 hrs- "x" distance at 46,600 (vs pre-planned 47,600). Boom observation as foHows: Bob M @ "3" (Carey moved to "7") heard I boom Carey at "07" 1 really intense boom, Micah @ '11' a double crack, and Bob L @ " 19" boom and pop. Observations suggest focus at T-1000. Ron Foster (controller) noted a/c "MP" call ~1.5 sec early. ARDS Pod info off and on controller screen (Ridley 1st-2nd floor problem again-but O.K during most of run inbound. A/C hdg almost on 270° T (~272°) and track right on. A/c ~ 0.3 n.mi N. of OH (of target)

Run 2 CB64/23:58:59 hrs - "x" distance at 44,100' (vs pre-planned 46,100' or pre-flight distance of 45,100'). Made decision to move "x" 1,000' closer to target based Run 1 and a/c accel. rate in PM. Boom observations as follows: Bob M @ "3" heard low level boom and a/c noise, Carey @ "7" a strong boom, Micah at "11" a ba-boom, and Bob L @ "19" 3 booms. Appears focus at "T". Ron again noted a/c at MP 2 sec early. A/C track essentially same as Run 1. Straight/Smooth.

Run 3 CB64/00:06:09 hrs- "x" distance set at 42,500' (vs pre-planned 44,500' and pre-briefing 43,500'). Boom observations as follows: Bob M @ "03" rolling thunder, Carey @ "07" 1 boom of less intensity than Run 2, Micah @ "11" (Target) heard a big ba-boom, and BobL at "19" triple boom. Observations suggest focus right on target. Ron shows a/c "MP" call still 2 sec early (consistent anyhow). Track right on target and hdg ~ 272° T. Great run-in.

End of Runs for Today and for Program
15 Sorties Total

Times of a/c (@ "IP and Over Target "O.H." (Zulu)

0730 ops

Run	IP	MP	BP	OH	
1	14:40:09	14:40:29	14:40:57	14:40:58	
2	14:47:00	14:47:10	14:47:39	14:47:40	close estimates
3	14:52:34	14:52:45	14:53:11	14:53:12	
4	14:58:06	14:58:15	14:58:40	14:58:42	

1630 ops

Run				
1		23:51:10	23:51:21	23:51:53
2		23:58:08	23:58:57	23:59:02
3		00:05:29	00:06:03	00:06:09